Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

1010 EMPIRE BUILDING | April, 1944 | PITTSBURGH, PA.

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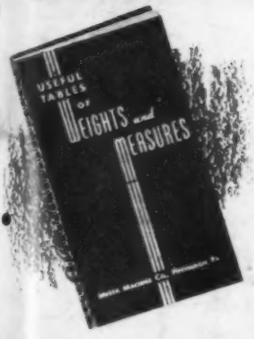
DETROIT

ONE OF THE MODERN
FOUR HIGH REVERSING PLATE MILLS
BUILT BY **MESTA**



Send for your copy of this 64 page booklet containing valuable engineering data. Address your requests to Dept. A-4

Mesta 110" Four High Reversing Plate Mill

Let's All Back The Attack—Buy More War Bonds

ARMY E NAVY

The Army-Navy "E" Flag with four stars, flies over the Mesta plant

MESTA MACHINE COMPANY
PITTSBURGH, PA.

One Way UNITROL Saves Time, Space and Trouble

You can get two or three times as much control into the same space . . . with UNITROL. You can have a complete, flexible, accessible control center without building for it . . . with UNITROL. And you will get a new concept of maintenance and inspection speed . . . with UNITROL. For many other UNITROL advantages, ask for the UNITROL Book.

What your factory needs TODAY
What it must have TOMORROW . . .

UNITROL

● Wondering what you can do about more plant space? Wondering how to get more work out of an already overburdened electrical maintenance crew? Wondering how to be best prepared for the production layout your plant will require tomorrow? UNITROL can contribute a great deal to the solution of these and many other vexing production, design and maintenance problems. UNITROL may disclose important space you didn't know you had. UNITROL can lift a big load off the shoulders of harried, hurried electrical men. UNITROL will help you to many short cuts in shifting, changing, replacing or rebuilding your plants' motor control facilities in line with changing needs. If you don't know *all about* this pioneering, unitized, sectionalized method of mounting, housing and centralizing motor control, a request for the UNITROL Book should be your first order of business. Many of today's leading plants say UNITROL is the next step forward in modern motor control practice; the UNITROL Book has a wealth of time, money and work saving ideas. Send for a copy today . . . CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
UNITROL
C-H

Copyright 1944, Cutler-Hammer, Inc.

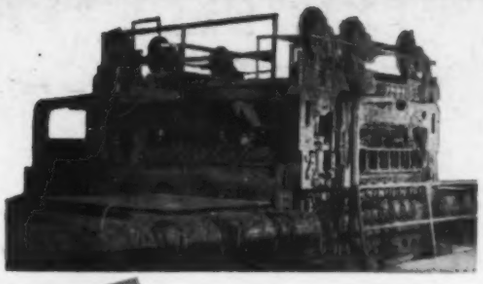
UNITROL and your filing cabinet system have much in common

You can easily change the contents in any drawer of your filing cabinets. You can easily add, subtract or change sections. And you can easily go from one drawer to another. UNITROL is that kind of a cabinet filing system for Motor Control . . . its value to *any* plant already proved in *hundreds* of plants

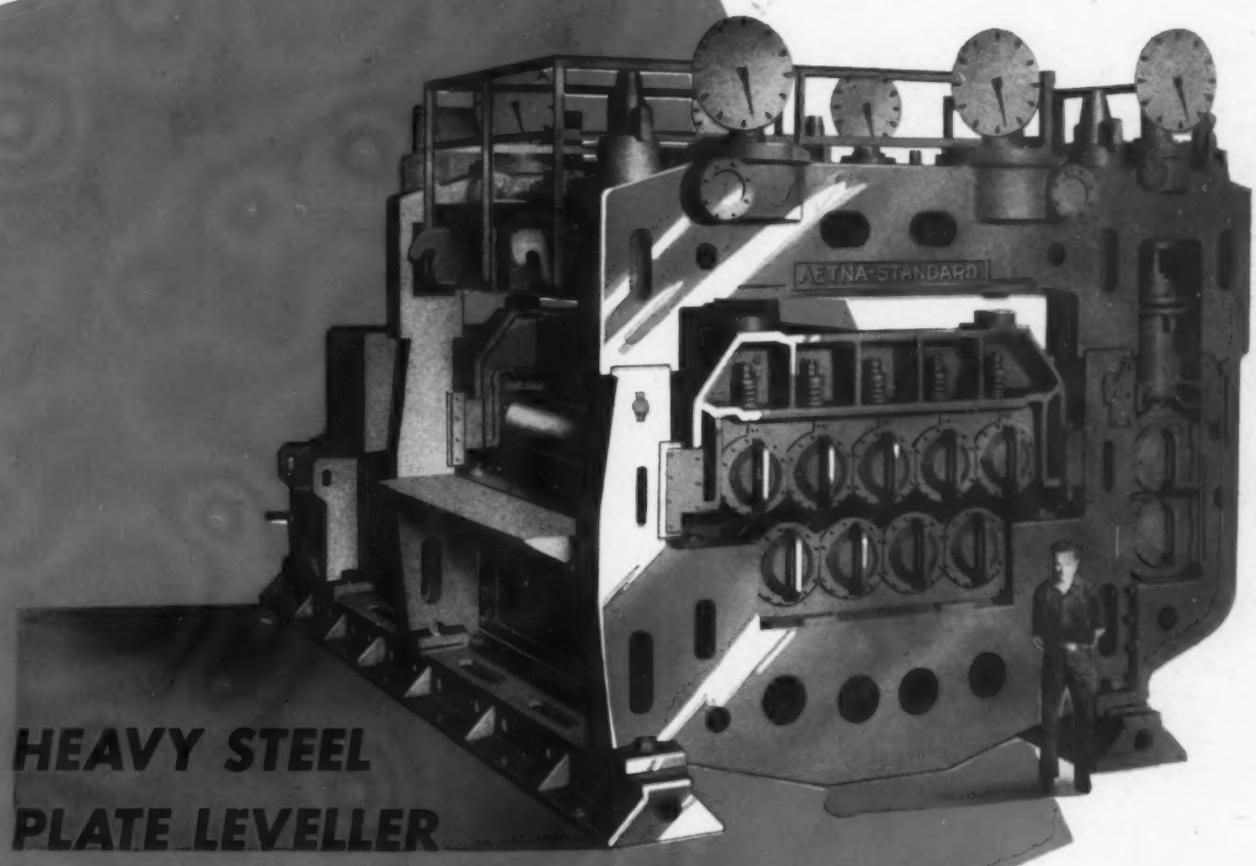
Engineering Excellence Finds its Greatest Reward in the Respect and Confidence of those it Serves

FACTS ABOUT AETNA-STANDARD

The Aetna-Standard Engineering Company builds and installs all sizes of two-high and four-high levellers. Included are small sizes for tin plate, and larger types for heavier gauges such as the one described below.



THERE'S ALWAYS SOMETHING NEW AT AETNA•STANDARD



HEAVY STEEL PLATE LEVELLER

This 200-ton giant flattens hot, heavy, alloy plates as fast as they come from the rolling mill . . . 100 to 300 feet per minute.

Plates ranging in thickness from ¾ to 1¼ inches can be levelled by the powerful action of the 140-inch rolls which move on anti-friction bearings. Each roll is 18 inches in diameter. A special designed motor screw-down enables the operator to readily adjust the top bank of five rolls in any direction.

This production machine was designed, built, and installed in record-breaking time . . . another example of Aetna-Standard precision engineering at work. The thousands of tons of ship plates, processed through this leveller, passed the rigid inspection standard with flying colors.

The AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN · OHIO · U.S.A.
ARMY E NAVY

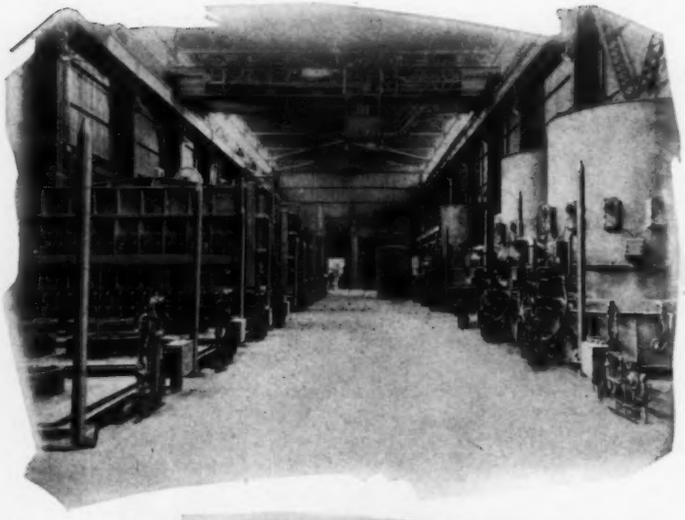
DESIGNERS AND BUILDERS TO THE STEEL NON-FERROUS AND CHEMICAL INDUSTRIES

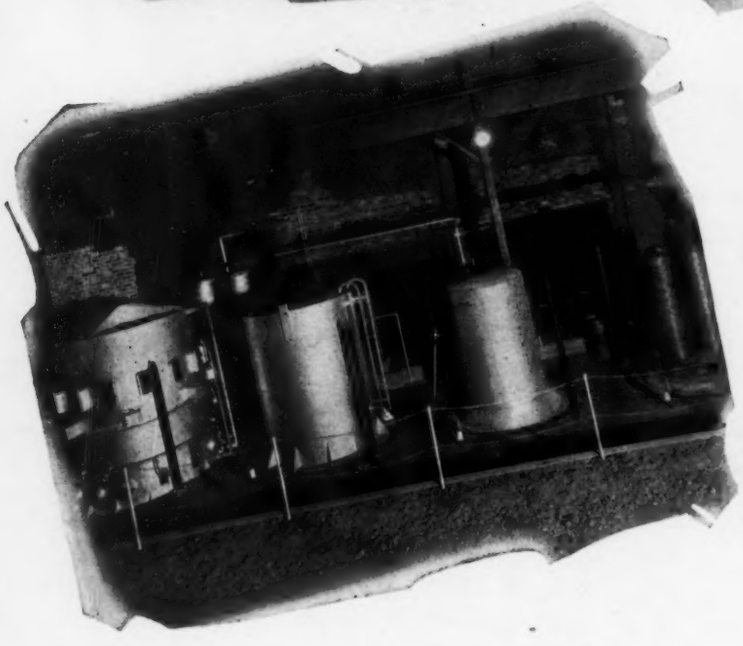
ASSOCIATED COMPANIES:

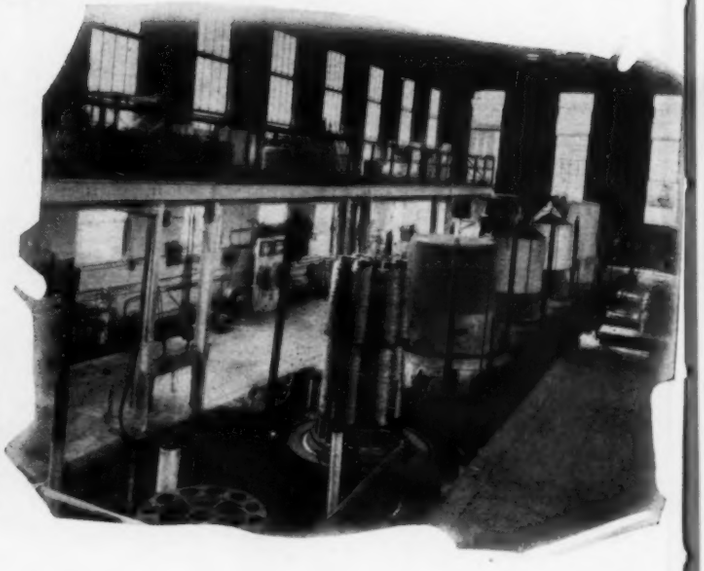
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

BELL TYPE ANNEALING
WILSON *Furnaces*

SINGLE STACK OR MULTISTACK DESIGN *for* RODS TO FINE WIRE







ENGINEERED AND CONSTRUCTED BY THE

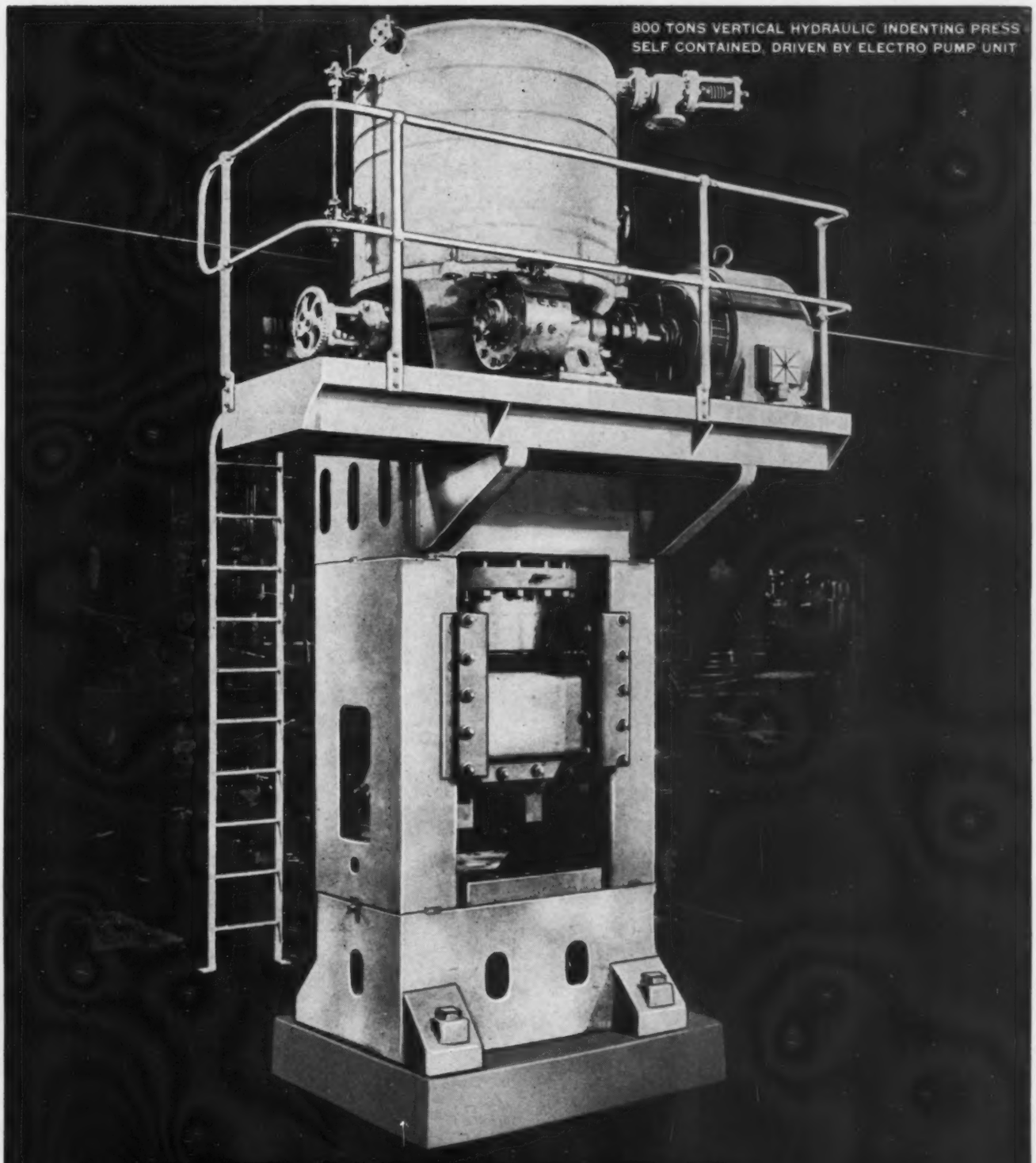
Lee Wilson ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

The Wilson Annealing Unit is covered by Patents Nos. 1,952,402, 2,068,477, 2,078,356, 2,081,612, 2,089,843, and other patents pending

INDUSTRIAL FURNACES ★ RADIANT TUBE HEATING ★ HEAT TREATING PROCESSE



HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
STRETCHERS · PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.

Micromax Pyrometers reporting on the temperatures in a battery of sheet-annealing furnaces. Big users of pyrometers — the men who know most about them — are very apt to prefer Micromax, because they're dependable and because the amount of time saved in servicing each instrument adds up to a substantial total for a battery.

depends on me!

A Slogan For Every American

For "ALL-OUT" HELP TO BUSY MEN

Micromax Can Solve the PYROMETER problem

Ability to hang onto temperature; to report it accurately and control it steadily, is backed up, in Micromax Pyrometers, by a number of specific features:

1. Any operator who can regulate a furnace manually can rapidly adjust the Micromax so that it relieves him entirely of temperature-controlling.

2. No operator has to remember the service needs of Micromax. Its most vital need — the standardizing of its measuring circuit, which all potentiometers require and which is a big reason for potentiometer dependability — is attended to by Micromax itself, automatically. This is done oftener than a busy man would do it, and is always done with utmost accuracy — the human element is thus simply wiped out of this important operation.

3. The operator is automatically reminded when one of the seldom-recurring service needs arises. A telltale calls his attention if electric power to the Controller is shut off; another lets him know when a new dry cell is needed. Well in advance he sees the need of more ink or fresh chart. He is cautioned *not* to lubricate the machine frequently, and unless he deliberately leaves its door open in a dusty atmosphere he may not clean it for months at a time.

4. Micromax is micro-responsive across its entire range; its temperature record is often so straight that only the fluctuations which it causes in the flow of fuel to the furnace, show the true sensitivity of the Pyrometer.

Micromax is available in four models, in addition to the Strip-Chart instrument shown here. One or another of them will meet any pyrometer need. If you have a problem, outline it and an L&N engineer will either send the appropriate catalog or give a more specific service, as you prefer.

These five Micromax Pyrometers regulate the temperatures of enormous metallurgical furnaces in an Ohio steel mill. Foreman has just changed the control point of one; is locking case to be sure his "orders" aren't changed.

Jrl Ad N-33(45)

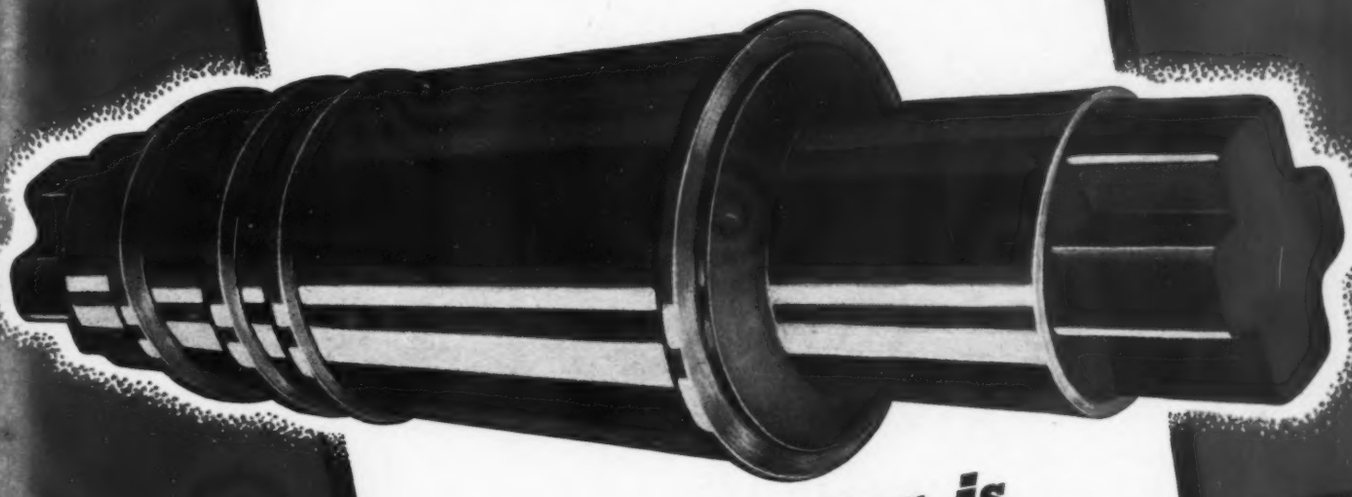
LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

when your problem is...

Higher Tonnage, Greater Toughness, Less Firecracking, Less Reduction Per Dressing, and Added Roll Strength for Blooming and Roughing . . .



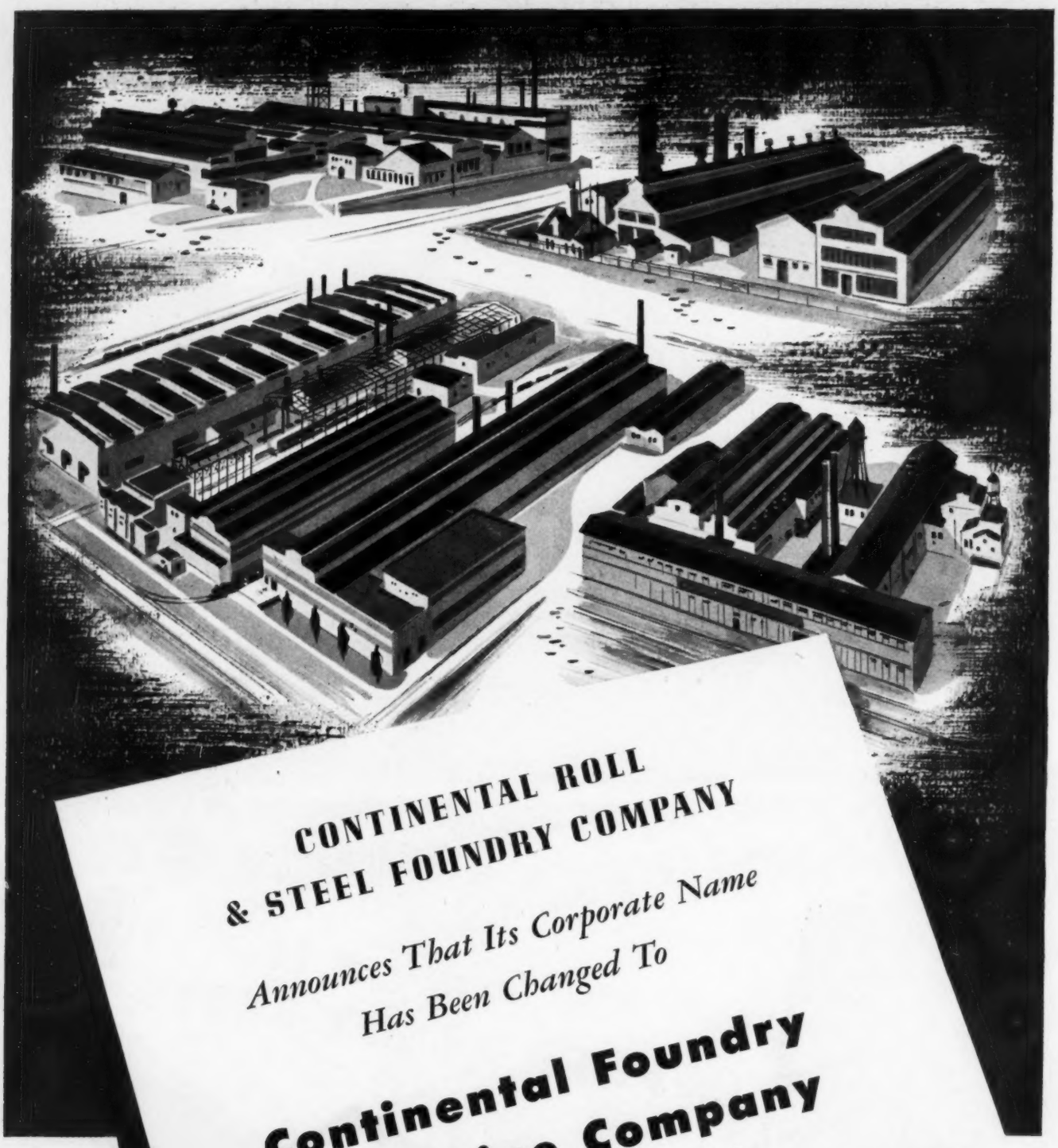
the Answer is COPPER-ALLOY STEEL

BIRDSBORO 40 ROLLS

BIRDSBORO STEEL FOUNDRY AND MACHINE CO. Birdsboro and Reading, Pa.

BIRDSBORO

ROLLS



CONTINENTAL ROLL
& STEEL FOUNDRY COMPANY

Announces That Its Corporate Name
Has Been Changed To

Continental Foundry
& Machine Company

Manufacturers of Carbon and Alloy Steel Castings, Rolls, Rolling Mill Equipment and Special Heavy Machinery ★ 4 Plants located at East Chicago, Indiana, Coraopolis, Pa., and Wheeling, W. Va.

ARMY E NAVY

Continental Foundry & Machine Company

SHE sure is, Soldier. That Pennsylvania Transformer is a "beaut", and for good reason, too. You see, we think appearances are important — even in transformers. Take, for instance, the one you're looking at — one of the 12,500 KVA's we built for the Bonneville Power Administration. That transformer was designed for performance, but it was also designed for beauty.

You see, Soldier, design can be functional as well as beautiful. The radiators on that transformer are a good example of what we mean. Their job is to cool and distribute the oil. They could very well have been placed on one or two sides of the tank and still comply with all engineering requirements, but our Engineers placed them all around the tank. Why? Because they look better that way and because they distribute and cool the oil with greater uniformity.

Here's another way we look at it, Soldier. Most transformers are located outdoors where they can be seen. The appearance of a transformer has a lot to do with the appearance of a substation. Look at those three banks of 12,500 KVA's — they sure do look good!

Yes, we agree with you Soldier. When you look at a Pennsylvania Transformer, you have good reason to exclaim: "Say, isn't she a beaut!".

Three banks of Pennsylvania Transformers totaling 112,500 KVA—115 KV Class.

* Steam

* This is the 9th of a series of informative messages concerning the meaning and significance of commonly used tests and terms employed to describe the characteristics of lubricating oils.

SCIENTIFICALLY ENGINEERED FOR EVERY INDUSTRIAL USE **TYCOL**

emulsion

TIDE WATER LUBRICANIA

DEFINITION: The A.S.T.M. Steam Emulsion Number (S. E. No.) is the number of seconds required for an oil to separate when emulsified with condensed steam and separated under definitely prescribed conditions.

TEST: A predetermined volume of the oil is placed in a test tube of prescribed size, which in turn is placed in a bath of water. A steam delivery tube is inserted into the oil extending to the bottom of the container. Steam is passed into the oil at such a rate as to maintain the temperature of the oil at 190-195°F. until the volume of the emulsion of oil and condensed steam is 40 ± 3 ml. The test tube containing the oil is next transferred to a separating bath maintained at a temperature of 200°F. to 203°F. The contents of the oil container is examined every 30 seconds. The time in seconds required for the separation of the 20 ml. of oil is reported as the A.S.T.M. Steam Emulsion Number.

SIGNIFICANCE: (S. E. Number) when applied to an unused oil indicates whether certain compounds (soaps, sulphonates and other emulsifying agents) or contaminants in an oil have been removed in the refining process. Changes in S. E. Number may occur during storage as well as in service. It may be stated that in general, the S. E. Number is not necessarily related to the oil's performance characteristics as a lubricant.

S. E. Number is sometimes included in the specification for certain oils, but there is no uniformity of opinion as to its practical value. This test as applied to used oils may be considered as of little significance.

Tycol lubricants are made from the most suitable materials. They are scientifically refined to meet stringent laboratory specifications and the recommended service requirement. It is this combination that assures the outstanding performance of Tycol Industrial Oils and Greases.

TIDE WATER ASSOCIATED OIL COMPANY

MAKERS OF THE FAMOUS VEEDOL MOTOR OIL • Eastern Division: 17 Battery Place, New York 4, N. Y.

Principal Branch Offices: **Boston, Philadelphia, Pittsburgh, Charlotte, N. C.**

INDUSTRIAL LUBRICANTS

"UNIVAN"

That Tough Steel

Tougher than a Century of Storms

Ancient and battle-scarred, this defiant old tree still stands up against nature's worst. That takes *toughness*—the kind of toughness and long life you'll find in "UNIVAN". Castings made from this Alloy steel scientifically heat-treated have proven in countless applications that they can absorb heavy shock and severe stresses with notable lack of fatigue. Where the going is tough specify "UNIVAN"—that tough steel. Make use, too, of Union's long experience in fabricasting intricate designs.

ARMY E NAVY

For Long Life with Economy
Specify "UNIVAN"—*that Tough Steel*

UNION STEEL CASTINGS

DIVISION OF
BLAW-KNOX CO.
PITTSBURGH, PA.

MAKERS OF Driving Wheel Centers, Locomotive Frames, Pump Casings, Vault Doors and Frames, Annealing Boxes, Spindles, Coupling Boxes, Open Hearth Charging Boxes, Gear Blanks — and other Castings for Steel Mills and General Industry.

ALL RECTIFIERS ARE NOT ALIKE!

ONLY ALLIS-CHALMERS EXCITRON GIVES YOU:

☛ "Continuous Excitation": No ignition impulses to be synchronized with main anode voltage. Tubes *do not* require re-ignition on each positive half-cycle.

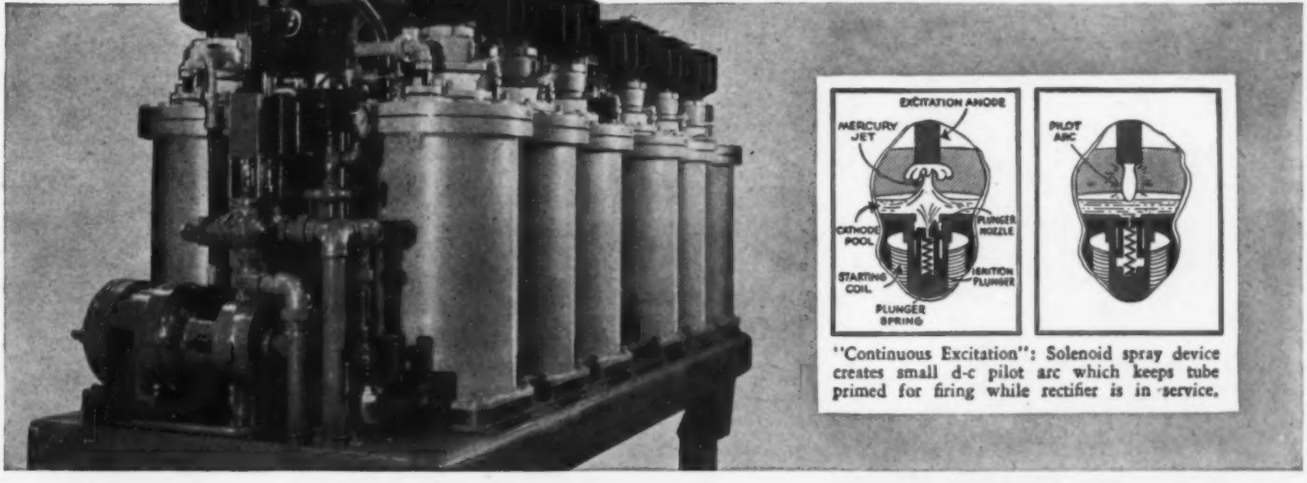
☛ Stability of excitation: Not affected by average single phase dips in a-c system voltage—nor system voltage wave shape. Excitron uses direct current from a 3-phase source for excitation of tube.

☛ Simple excitation circuit: No "tuning" to maintain proper wave shape. Once adjusted and tested at the factory, *no further adjustment* is needed in the field.

☛ Fixed excitation anode: Above and not touching hot mercury supply. Anode *cannot be affected* by any coating or turbulence on surface. No critical anode location which might require external adjustment or special care.

☛ Allis-Chalmers engineers introduced mercury arc rectifiers to U. S. industry. Consider Excitron for all power conversion. Allis-Chalmers, Milwaukee 1, Wis. A 1716

♪ *Tune in the Boston Symphony, Blue Network, every Sat. Eve.*



"Continuous Excitation": Solenoid spray device creates small d-c pilot arc which keeps tube primed for firing while rectifier is in service.

ALLIS-CHALMERS EXCITRON MERCURY ARC RECTIFIERS

EXPERIENCE is defined by the dictionary as "knowledge gained by trial." A lot of it is necessary to build quality all-welded cranes.

Behind every all-welded Cleveland Crane now being built there are 45 years of general crane experience and 18 years of experience in the all-welded steel construction.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

THE recent stand of selective service on the question of deferments for young men indicates that the production battle is now considered secondary to the actual use of armament in combat. Reports from almost every steel producing area look to a drop in production because of the manpower shortage. Some companies are considering closing or at least cutting back on certain auxiliary departments so as to free employees for more vital departments.

▲

IN spite of bad news from draft boards regarding deferments of its young men and in spite of a rash of wildcat strikes which seem to be an accompaniment of the WLB hearings on the "Little Steel formula," the steel industry of the United States in March came close to a new monthly record for ingot production, with a total of 7,804,704 net tons. It has been estimated that this figure suffered by about 16,000 tons in the Pittsburgh district alone because of short, unauthorized strikes, one of which was instigated by the moving of an American flag from under a crane runway where it was a target for grease dripping from the crane. There is no question but that the record of 7,819,061 tons set last October would have been broken had it not been for strikes. Anyone wanting to claim credit for the near miss, please step forward.

▲

MARCH plate production was also a record with total shipments of 1,226,606 net tons as compared with the previous record of 1,174,414 tons in January. Included in March shipments were 546,292 tons of strip mill plates, 546,670 tons of sheared mill plates and 129,644 tons of universal mill plates.

▲

RECOGNIZING those two inevitables, death and taxes, WPB is now permitting the use of 10 lb of iron and steel in a casket as against a previous 3½ lb. Also, perhaps by way of helping the Treasury Department make us come clean, WPB has approved the manufacture of 50,000 cast iron bathtubs and $27,000,000 worth of commercial laundry equipment.

▲

WHILE world oil reserves may be adequate for many years to come, a recent report by the National Bureau of Economic Research indicates that the United States has enough oil for only a few decades, and unless new fields are found, the United States must soon import oil.

▲

PROPHECY is a commodity for which industry spends so much with so little return, according to Raymond Moley in addressing the Pittsburgh Advertising Club recently.

▲

BITUMINOUS coal stocks held by consumers has dropped to a new wartime low based on average number of days supply. By-product coke ovens are now said to have 24 days supply as compared to a 39 day supply a year ago. Steel plants and rolling mills now hold a 22 day supply against a 29 day supply last year. Average daily consumption in February is reported as 261,483 tons for by-product coke ovens, 34,931 tons for beehive coke ovens, and 34,241 tons for steel and rolling mills.

▲

THE reception accorded "The Modern Arc Furnace," published in the Iron and Steel Engineer for February has exceeded all expectations. Approximately 3000 reprints of this article have been distributed throughout the electric furnace field. A limited quantity of the reprints is still available.

▲

NO relaxation is to be expected in the near future of any of the limitation orders affecting tin cans, steel drums, pails and metal closures, according to WPB's Container Division.

▲

AIDED by amended regulations from WPB, the twenty-two rail rerolling mills in the country have taken a new lease on life and are now producing over 40,000 tons of rerolled products per month, approximately twice that of a year or more ago.

▲

A NEW record total of 215,600,000 lb of fabricated aluminum products was shipped during January of this year, 34 per cent more than the corresponding month last year. Sheets showed the greatest rise with 85,000,000 lb being shipped against 66,900,000 lb during December, 1943. More than 44,000,000 lb of aluminum castings also were shipped during January.

▲

OUT of every seven tons of steel currently produced, approximately one ton is alloy steel.

▲

A TOTAL of 9118 airplanes of all types was produced during March, setting an all-time monthly record. Of this total 86.5 per cent were tactical types, representing bombers, fighters and transports.

MONTHLY TONNAGE REPORT
SERIES 4000
FOR LIGHT and MEDIUM SCARFING
SERIES 5200
FOR REMOVAL OF LARGE AREAS OR HEAVY WASHING
SERIES 6100
FOR HEAVY SLAB SKINNING OR PREHEATED STEELS

3 Keys TO BETTER SCARFING TONNAGE FIGURES

As pioneers in the development of the oxyacetylene process of surface conditioning blooms, slabs and billets preparatory to rolling, Airco has continued to perfect the apparatus required for its practical application.

The three flame scarfing torches shown above are good examples of that Airco service to the steel industry. They represent the combined effort of the Airco Apparatus Research Department, Airco's Field Engineering Service Staff and practical steel makers to provide the most efficient equipment for light, standard or heavy hand deseaming.

They are designed for billet shed service, light but sturdy and balanced to enable the operator to work with maximum speed and efficiency.

Ask your nearest Airco office for new catalog circular illustrating and describing these three important aids to better scarfing tonnage figures — or write direct to Dept. S1 of

★ BUY UNITED STATES WAR BONDS ★

AIRCO WILSON

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON 1, TEXAS

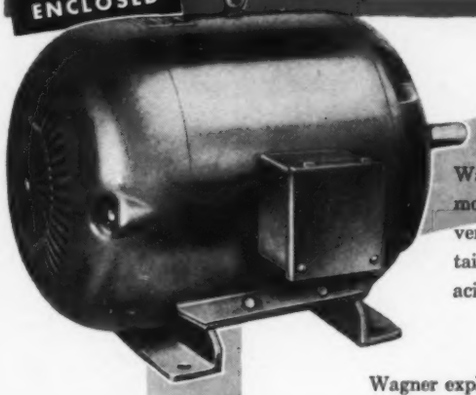
Offices in all Principal Cities

FOR THOSE "TOUGH JOBS"

WHERE THE SURROUNDING ELEMENTS ARE DESTRUCTIVE OR HAZARDOUS

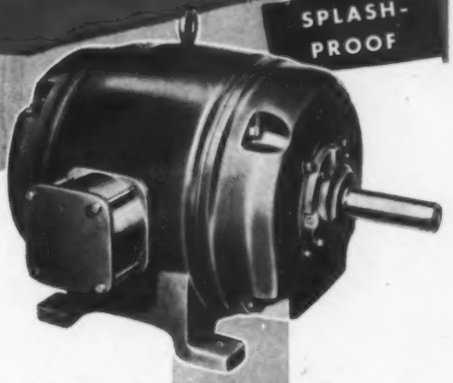
use Wagner MOTORS

TOTALLY-ENCLOSED



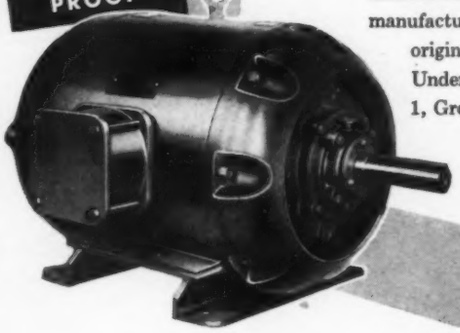
Wagner CP totally-enclosed fan-cooled motors are designed to operate under adverse conditions in atmospheres that contain dust, dirt, abrasives, steel chips, filings, acid fumes, and other harmful elements.

SPLASH-PROOF



Wagner splash-proof, squirrel-cage polyphase motors are built to operate dependably in locations where they are subject to splashing water, oil, or other liquids. They are widely used in unprotected outdoor locations, being designed with complete self-protection against rain, snow and sleet.

EXPLOSION-PROOF



Wagner explosion-proof polyphase motors are designed to operate in locations where "flammable volatile liquids, highly flammable gases, mixtures or other highly flammable substances are handled or manufactured, used or stored in other than original containers." Approved by the Underwriters' Laboratories for Class 1, Group D hazardous locations.

CHEMICAL-PROOF

Wagner chemical-proof motors are of totally-enclosed, fan-cooled construction and designed to resist the action of acids, fumes, moisture and other harmful elements encountered in chemical manufacturing. A moisture-proof and dust-tight conduit box protects the motor against dust, fumes, or moisture. Special drain plugs in end-plates and conduit box are provided for removing any condensation from the motor or conduit box.

MOTORS
TRANSFORMERS
UNIT SUBSTATIONS
INDUSTRIAL BRAKES
BRAKE LINING

M44-8

Write FOR BULLETINS MU-182 and MU-183

Everyone interested in electric motors should have Wagner Bulletins MU-182 (Wagner Polyphase Motors) and MU-183 (Wagner Single-Phase, Direct-Current, and Small Polyphase Motors). Helpful information also will be found in Bulletin MU-26A (Instructions for Installing and Operating Wagner Polyphase Motors).

ARMY E NAVY

NATIONAL SECURITY AWARD

Wagner Electric Corporation

ESTABLISHED 1891

6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS

Hey! Just a Moment—

This job has been effectively MECHANIZED

BY

THE BONNOT CO.

CANTON, OHIO

SAVE TIME
CLEAN 20 BILLETS TO ONE THE OLD WAYS

SAVE MEN
FOR OTHER IMPORTANT JOBS

SAVE METAL
SALVAGE WHOLE HEATS THAT GO BAD

SAVE POWER
A 60 PER CENT KWH SAVING

BONNOT-LENTZ BILLETEERS

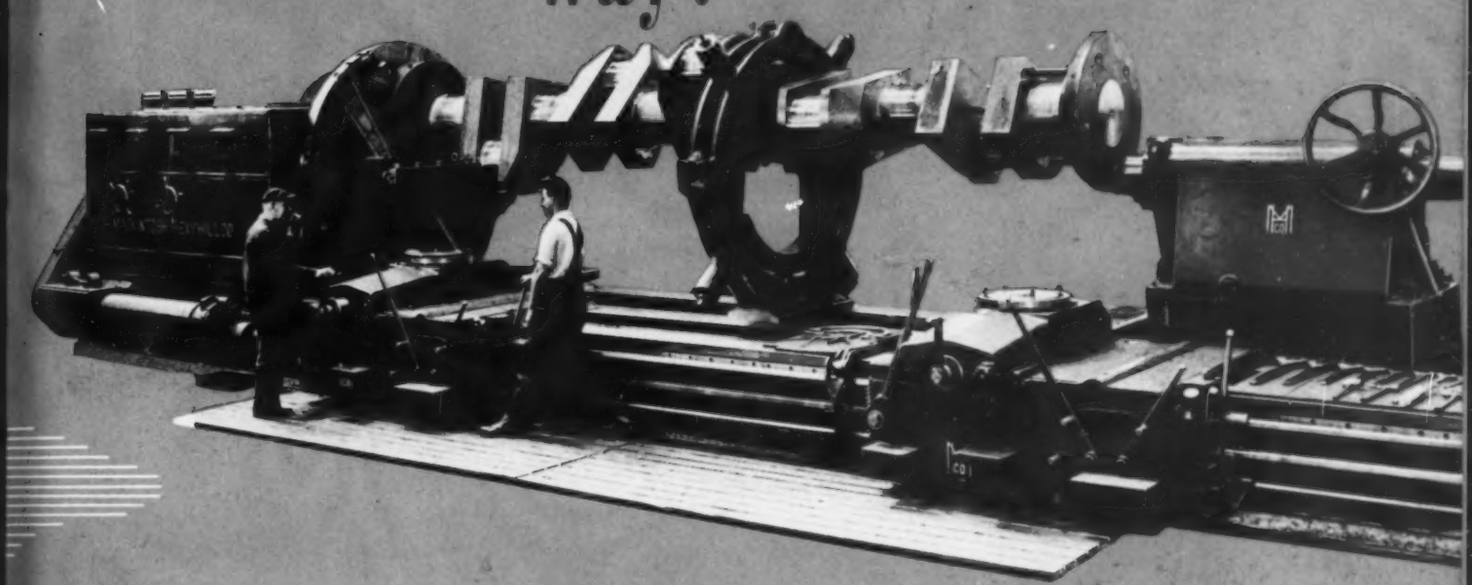
(IN THE BILLET CONDITIONING DEPARTMENTS OF THE LEADING STEEL PLANTS TODAY)

BONNOT

ENGINEERED FOR IMPROVED PRODUCTION

• The Billeteer feeds clean billets into mill schedules faster, at lower costs and man hours than by any other method. Write us for complete facts.

Have you thought about your profits this way?



America's enormous wartime increase in production efficiency has now become an industrial habit. It sets a new and much faster tempo for tomorrow's business battles. It means that your profits and place in post-war competition will be determined, to a greater extent than ever before, by the economical productiveness of your heavy duty equipment.

Now, is the time to prune your costs and Mackintosh-Hemphill can help you do it. In their sphere of manufacturing, metallurgy and engineering they are one of the world's leading sources of industrial developments. For instance, M-H double duty, heavy engine lathes will perform all conventional and many special turning and boring operations with remarkable efficiency. When rough cutting, their rate of stock removal on many types of work, is more than 50% faster than on regulation heavy duty lathes—and this without vibration or excessive strain on any part of the machine. Mackintosh-Hemphill offers you an efficient approach to all heavy duty equipment problems. Their advanced industrial thinking may be your answer to today's production schedule and tomorrow's market price.

MACKINTOSH-HEMPHILL COMPANY

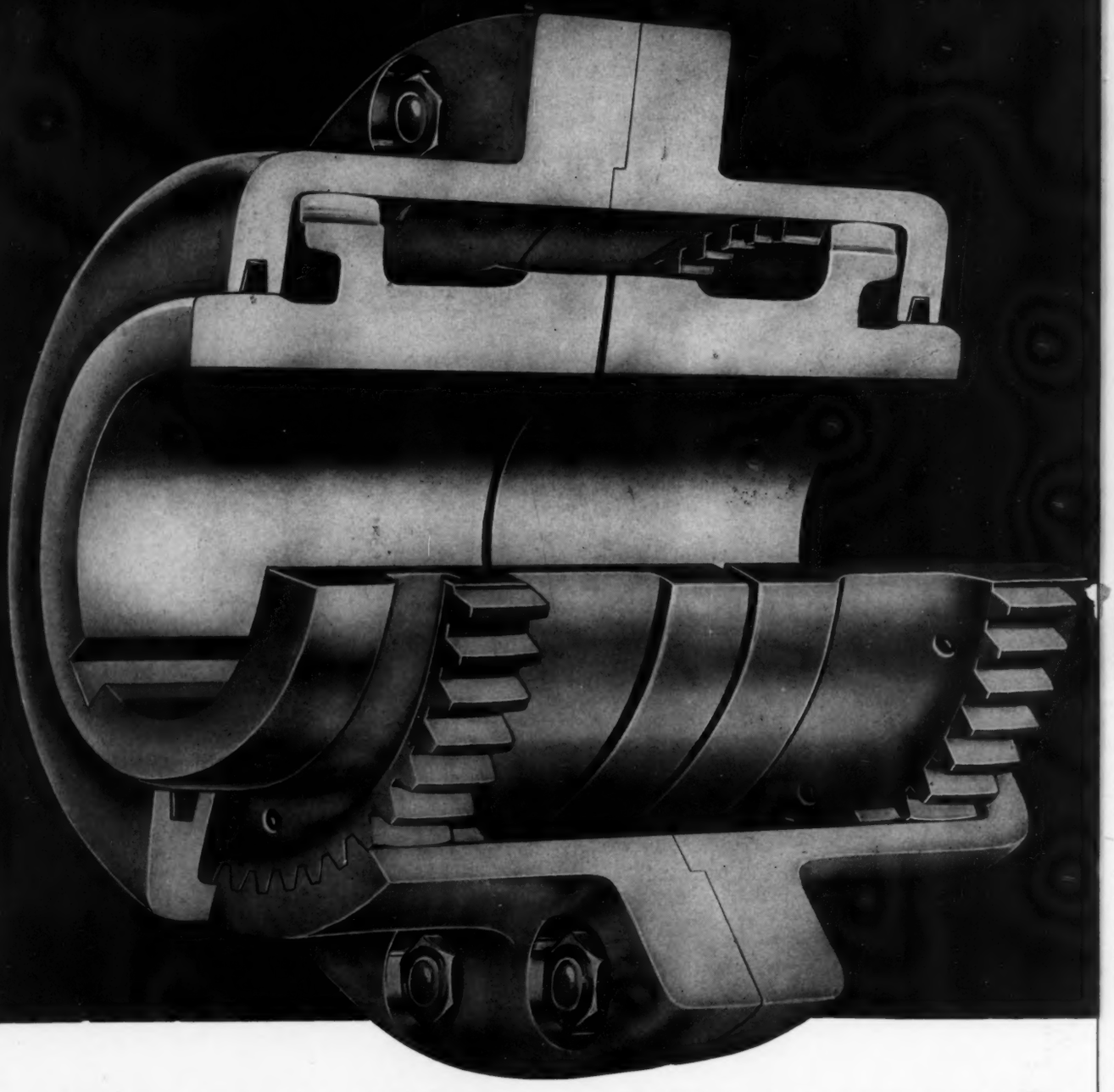
Pittsburgh and Midland, Pennsylvania

Makers of the rolls with the red wabblers

OTHER PRODUCTS:—Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports.

Mackintosh-Hemphill has been the originator of practically every major roll development . . . Their Nironite D Cold Mill Rolls are usable down to scrap size without the necessity of further heat treatment and resultant refinishing.

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUES

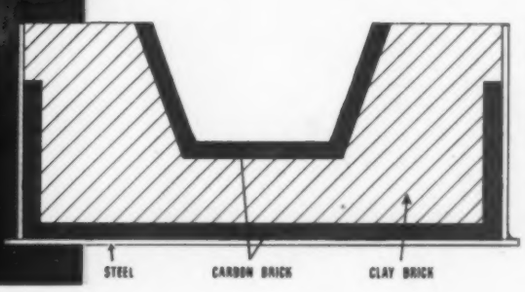
FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

6 months' service!

. . . for Carbon run-out troughs



CARBON LINED run-out troughs for blast furnaces are now giving six months of continuous service . . . instead of only a day or so for those of conventional construction.

Built up with carbon brick as shown in the cross-section sketch, the necessity for routine—and hazardous—rebuilding of the lining is eliminated. A stream of cold water on the hot iron fractures the metal for immediate removal and cleaning of the trough . . . with no harm to the carbon brick from thermal shock.

The reasons for the excellent service of run-out troughs built with "National" carbon brick are important. It is to your advantage to know them. For carbon and graphite are the ideal materials for many metallurgical applications such as furnace linings, mold plugs, stools, molds, and others. These reasons are:

- **Carbon retains its mechanical strength well past the highest temperatures attained in handling molten metals.**
- **Carbon is subject to no deformation under the pressures normally encountered at these temperatures.**
- **Carbon is unaffected by rapid and violent changes in temperature, for example: from 3300° F. to 0° F.**

"National" carbon and graphite have other important properties . . . and there are other applications . . . that greatly improve steel making and foundry practice and economy. Our offices are conveniently near and we cordially invite your inquiries. Also, write for our Catalog Section M-8000 "Industrial Applications," National Carbon Company, Inc., Cleveland 1, Ohio, Dept. 36D

★ *BUY UNITED STATES WAR BONDS* ★

The word "National" is a registered trade-mark of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

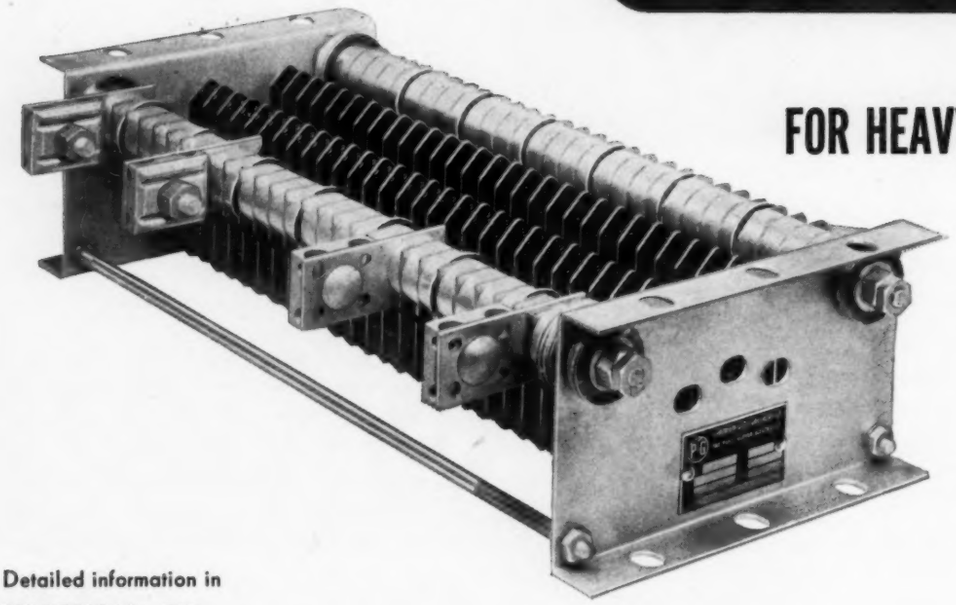
CARBON PRODUCTS DIVISION, Cleveland 1, Ohio UCC New York, Pittsburgh, Chicago, San Francisco

NONBREAKABLE

P-G

RESISTORS

in STEEL MILLS



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CHARGING MACHINES

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MILL TABLES

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ORE BRIDGES

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SAFETY LIMIT STOPS

Detailed information in
BULLETIN No. 500

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• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

A·B·K
Laminated Plastic Bearings
keep 'em rolling—at less cost

KEEPING Victory mills rolling 24 hours a day is a tough job. But not in mills using A-B-K plastic bearings.

A-B-K plastic bearings have established records for long service, for tonnage rolled, for eliminating lost time due to shutdowns and for reducing power consumption in large plants.

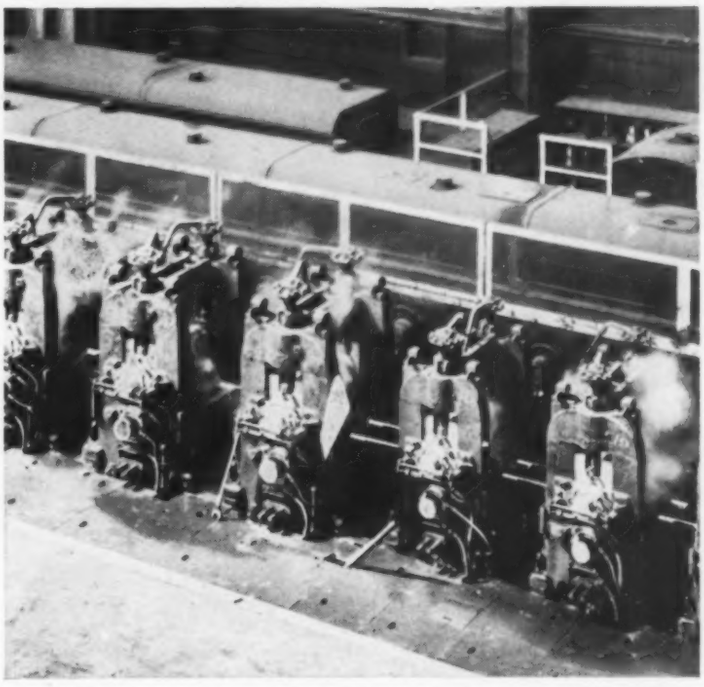
Materials used in A-B-K were developed by American Brakeblok research engineers to provide an unusually low coefficient of friction. A-B-K bearings are made to a tested formula in one of the most modern plants in America, and are furnished to size ready for installation without extra machining.

The research and engineering facilities of A-B-K are available for recommendations on your bearing problems. Write American Brakeblok Division, Detroit 9, Michigan.

Typical A-B-K Roll Neck Bearing with separate thrust collar.

A-B-K Patented Reinforced Edge Slipper Bearing, made in required sizes to blueprint.

Phantom View of A-B-K patented Reinforced Edge Slipper Bearing.



Industrial and Marine Uses
A-B-K Laminated Plastics

- Textile Mills
- Steel Mills
- Rubber Mills
- Industrial Truck Wheels
- Paper Mills
- Marine Stern Tube Bearings
- Pintle Bearings
- Rudder Bearings
- Etc.

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DIVISION OF AMERICAN Brake Shoe COMPANY

Section view: Note long distances from contact to contact and from contacts to ground.

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The circuit breaking plugs and receptacles . . . ratings up to 200 amperes

Pyle-National plugs and receptacles are built to stand up in mill service, delivering dependable service with minimum maintenance. The exclusive QuelArc construction provides exceptional protection to contacts, for safe use as current rupturing devices. In the section view, note the complete enclosure of all contacts in insulating chambers which form an arc-trapping space. Note also the long distances from contact to contact and from contacts to ground. Contacts are individually renewable. Full ground protection is provided.

QuelArc plugs and receptacles are available in a complete range of styles, 2, 3, 4 wire types; ratings 20, 30, 60, 100, and 200 amperes. Many other types available for portable tools and control and instrument circuits. Write for general catalog 1100 with listings of all types.

THE PYLE-NATIONAL COMPANY
1334-58 North Kostner Avenue • Chicago 51, Illinois
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CONDUIT FITTINGS • FLOODLIGHT PROJECTORS • LOCOMOTIVE ELECTRICAL EQUIPMENT

HOW TO SOLVE OPERATING PROBLEMS WITH *Correct Lubrication*

New Grease sticks on the Job!

WHEN hot steel slabs pass over this table, these bearings get the shock of their lives. And they also get heat and water in addition to the impact pressures.

Socony-Vacuum's new, patented Gargoyle Grease Sovarex L is specifically designed to meet heavy-duty steel mill service like this.

On table roll bearings—and on work and back-up roll bearings—this new grease resists shock loads and the softening effect of high temperatures and thus reduces wear and leakage. Strong films stick on the job, despite the washing effect of water. Minimum change in consistency permits easy feeding through long pipe lines with temperature variations.

Gargoyle Grease Sovarex L is proving itself in many mills now, standing up under temperatures as high as 450° F. and resisting rupture at high pressures. Why not take advantage of it in your mill? Your Socony-Vacuum representative will give you details.

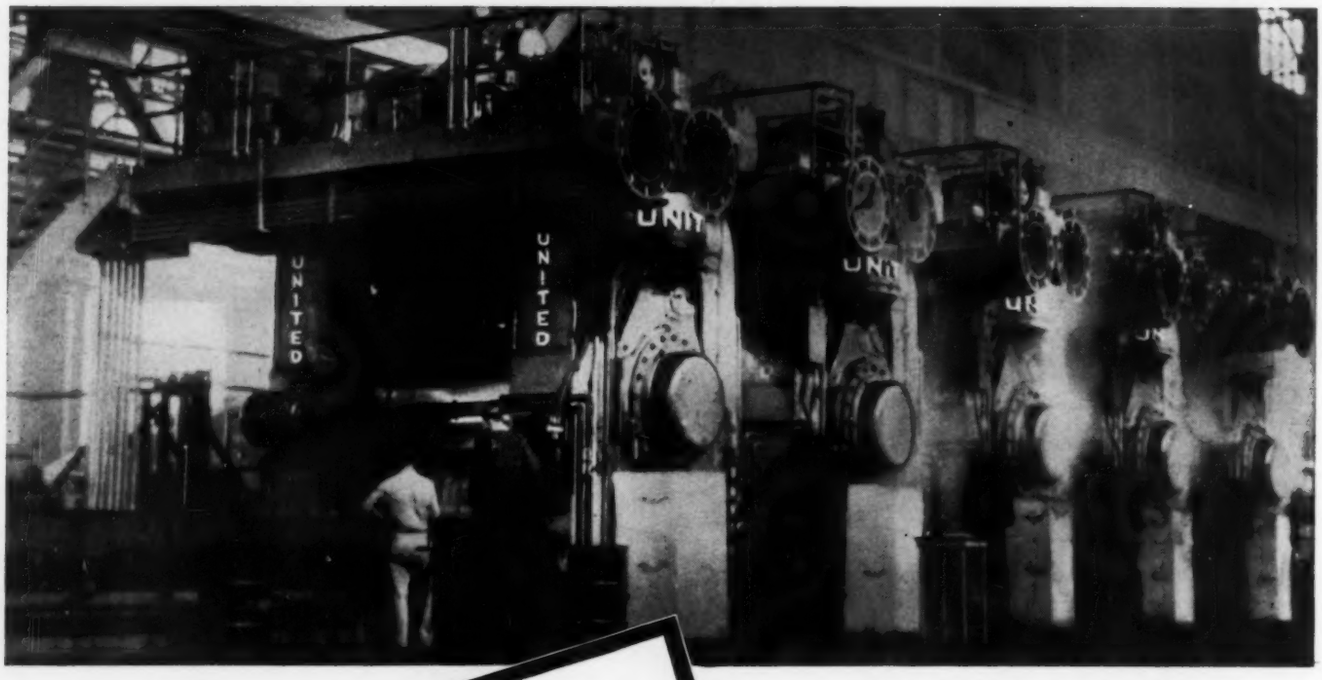
SOCONY-VACUUM OIL CO., INC., Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. • White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California.

GARGOYLE Lubricants

CALL IN SOCONY-VACUUM

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION

Hot Rolling Duralumin



● *80" 5-Stand Tandem Hot Mill built by United Engineering & Foundry Co.*

4 HIGH TANDEM HOT MILL—27½" x 54" x 80"

Back-up Roll Neck Mountings
31" x 48" x 33"

Work Roll Neck Mountings
18⅛" x 24⅜" x 14⅜"

SKF
BALL AND ROLLER BEARINGS

One of America's biggest duralumin rolling mills is literally "alive" with SKF Spherical Roller Bearings.

On work rolls and back-up rolls, drives and tables, cranes, etc., their built-in alignment compensates for shaft deflections, distortions and weave. Their high capacity and low friction speed the tonnage of vital duralumin.

The presence of SKF's is an indication of sound engineering practice. 5340

SKF INDUSTRIES, INC. • FRONT ST. & ERIE AVE. • PHILADELPHIA 34, PA.

SAVED—A FLOOD OF PRECIOUS SOLVENT... *and costs cut to one-tenth*

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A Cleveland paint maker, irked at seeing much precious solvent wasted with dirty paint and residue (reclamation processes then used were prohibitively costly), looked for a practical solution . . . and called a Bowser Liquid Control Engineer.

A Bowser Still, basically similar to those which Bowser makes for the dry-cleaning industry, was recommended . . . and installed. With it, thousands of gallons of solvents were reclaimed at a cost of only a few cents per gallon, about one-tenth of the old cost. At that rate of saving, the Still paid for itself in its first 150 hours of operation.

In the steel industry, Bowser lubrication for mill stands, pinion gear sets, reduction gears, turbines, etc., is so outstanding that it has been adopted for 90 per cent or more of all steel production in the United States. Bowser coolant systems are equally dominant.

The success of Bowser equipment in the steel industry is largely because Bowser installations are engineered to the exact needs of the operation. They become an integral part of the mill.

And here's an important point to remember—wherever your plant is located, you're close to a complete Bowser service organization. BOWSER, INC., Fort Wayne 5, Ind.

BUY WAR BONDS

THE NAME THAT MEANS **EXACT CONTROL** *OF LIQUIDS*

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THE HALLDEN MACHINE CO., Thomaston, Conn.
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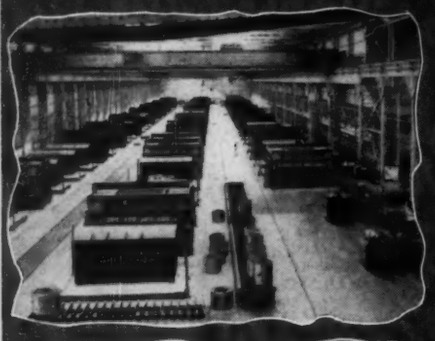

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- Uncoiling Units
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- Strip Coil Holders
- Strip Coiling Reels
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- Equipment for Chemically Treating Tin Plate
- Automatic Doublers
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SPECIALISTS IN SHEET, STRIP AND TIN MILL EQUIPMENT

now at your finger tips . . . 18 Westinghouse developments that are

Stepping up Steel production

Send for this new booklet today!

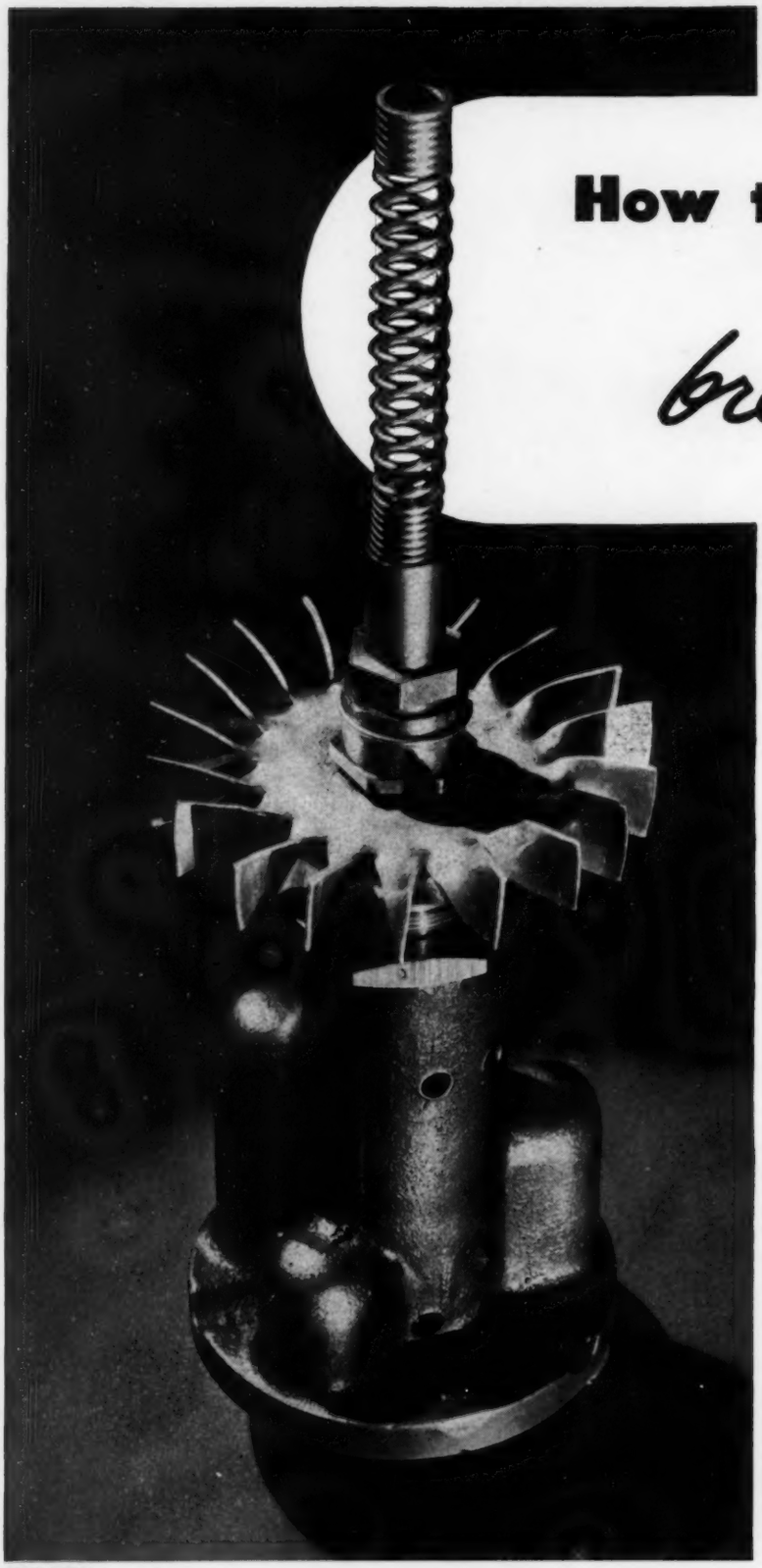
This new 32-page booklet tells the exciting story of 18 Westinghouse electrical developments that are keeping steel production at an all-time high . . . helping it go higher. Not only does this booklet give an over-all picture of the latest electrical advances in the modern steel mill, but it may suggest to you new applications for these developments.

The "IR Drop" system of speed control that makes possible the greatly increased speeds of today's cold rolling mill; the "tensiometer" that keeps tension uniform during continuous cold rolling; the pinhole detector that spots minute holes in strip speeding at 1000 feet per minute—these are just a few of the subjects covered.

Westinghouse Engineering Service has been working hand in hand with Westinghouse Engineering Research for decades to give the steel industry the great resources of electrical ingenuity. The developments outlined in this booklet are the result of the close co-operation of Westinghouse steel specialists with the steel industry. Read the story for yourself. Send for Booklet 3252, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. J-94618

Westinghouse

EQUIPMENT FOR THE STEEL INDUSTRY



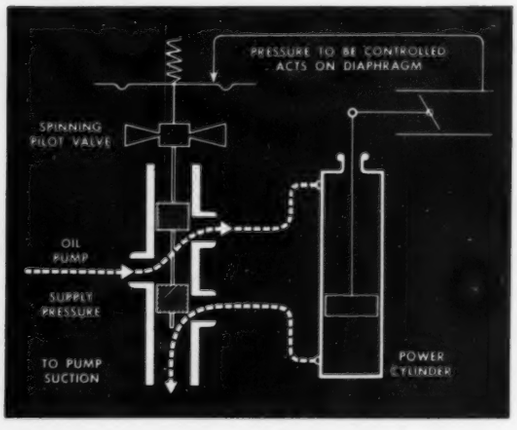
How to move a *ton* with a *breath* of air

A BIG open-hearth damper may have an unsprung weight of 2000 to 3000 pounds. When you think of moving such a weight to regulate furnace pressure within a *few thousandths of an inch water gauge,* it seems like an impossibility.

That's where the *Hagan Spinning Pilot Valve* goes to work. This unit and its external relay can produce a force amplification of 8,000,000 times. What's more, the amplification is obtained with no appreciable loss of accuracy. This is a remarkable achievement and results in the accurate, powerful action of Hagan Control.

In actual practice it means that Hagan Control operates quickly and positively—regardless of friction that may develop in the dampers. Full power of the piston is applied for even the smallest changes in pressure.

Hagan Spinning Pilot Valve assures the positive application of full pressure to the power cylinder so that the heaviest dampers can be regulated accurately for the smallest changes in pressure.

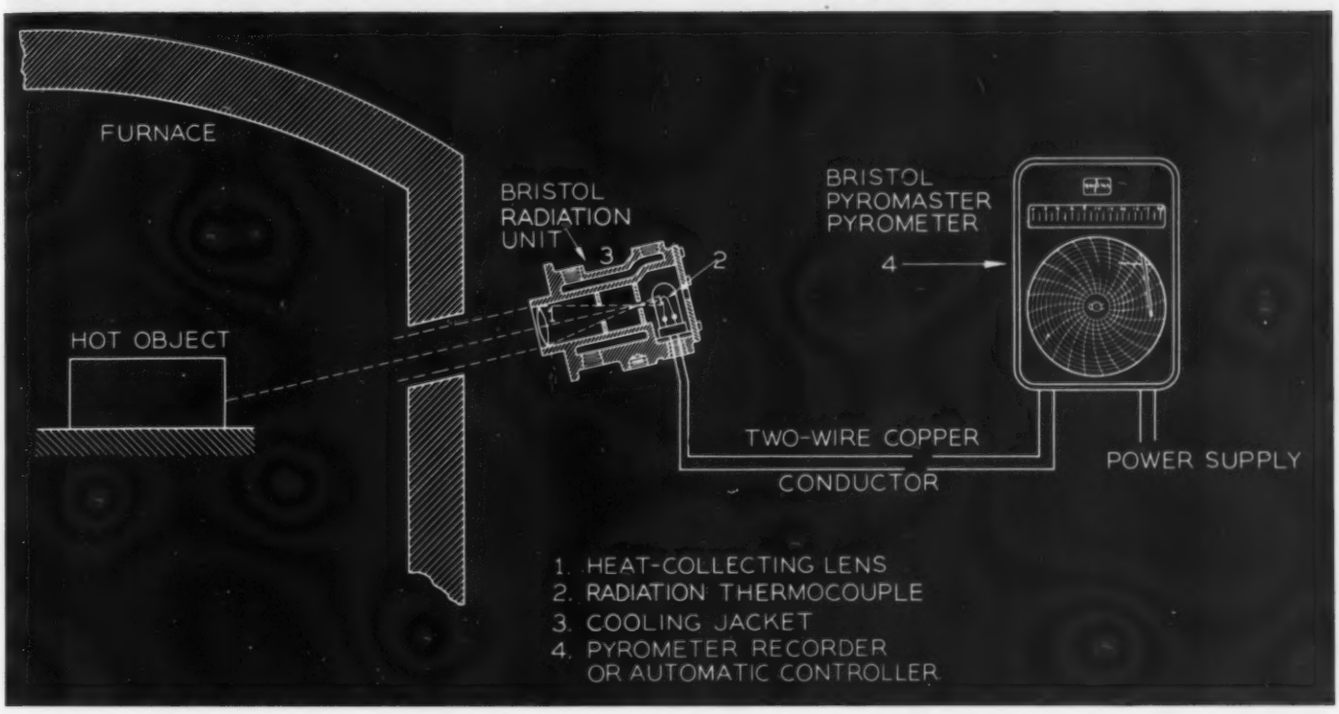


HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION · HAGAN BUILDING · PITTSBURGH 30, PA.

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader



HOW TO TELL THE TEMPERATURE OF A HOT STOVE WITHOUT SITTING ON IT

On Jobs where a Thermocouple is Impracticable, Bristol's PYROMASTER Radiation Pyrometer Gives Perfect Accuracy . . .

Where it's too hot for a thermocouple (over approx. 2800° F) . . . where there are space or other limitations . . . and for taking *surface* temperatures or temperatures of the "work" itself in a furnace—Bristol's PYROMASTER Radiation Pyrometer gives you accurate readings *from outside the hot zone.*

The temperature-sensitive element is mounted outside the furnace. Its lens picks up heat rays emitted by the hot object and focuses them on a thermocouple which in turn registers them on a Pyrometer.

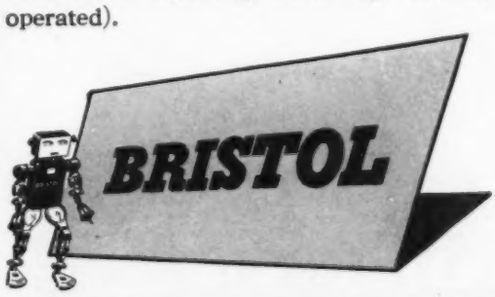
Readings are accurate because (1) the "sighting" element watches the temperature of the object itself, not the surrounding atmosphere; (2) the radiation unit is calibrated to within an accuracy well within that of commercial thermocouples; (3) the thermocouple used has so little mass that there is practically no time lag.

The complete unit rarely needs attention after once being properly sighted. Being out of the heat zone, there are no maintenance problems due to deterioration.

Models: recording, indicating, controlling (electric-type or air-operated).

APPLICATIONS

1. Stove dome temperature in blast furnace.
2. Open hearth roof temperature.
3. Ingot, billet, bar, and sheet temperatures:
   a. leaving heating furnace.
   b. entering rolls.
4. Checker temperatures:
   a. open hearth furnace.
   b. soaking pit.
5. Normalizing furnace in sheet mill.



. . . Gives YOU the Most from Heat

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

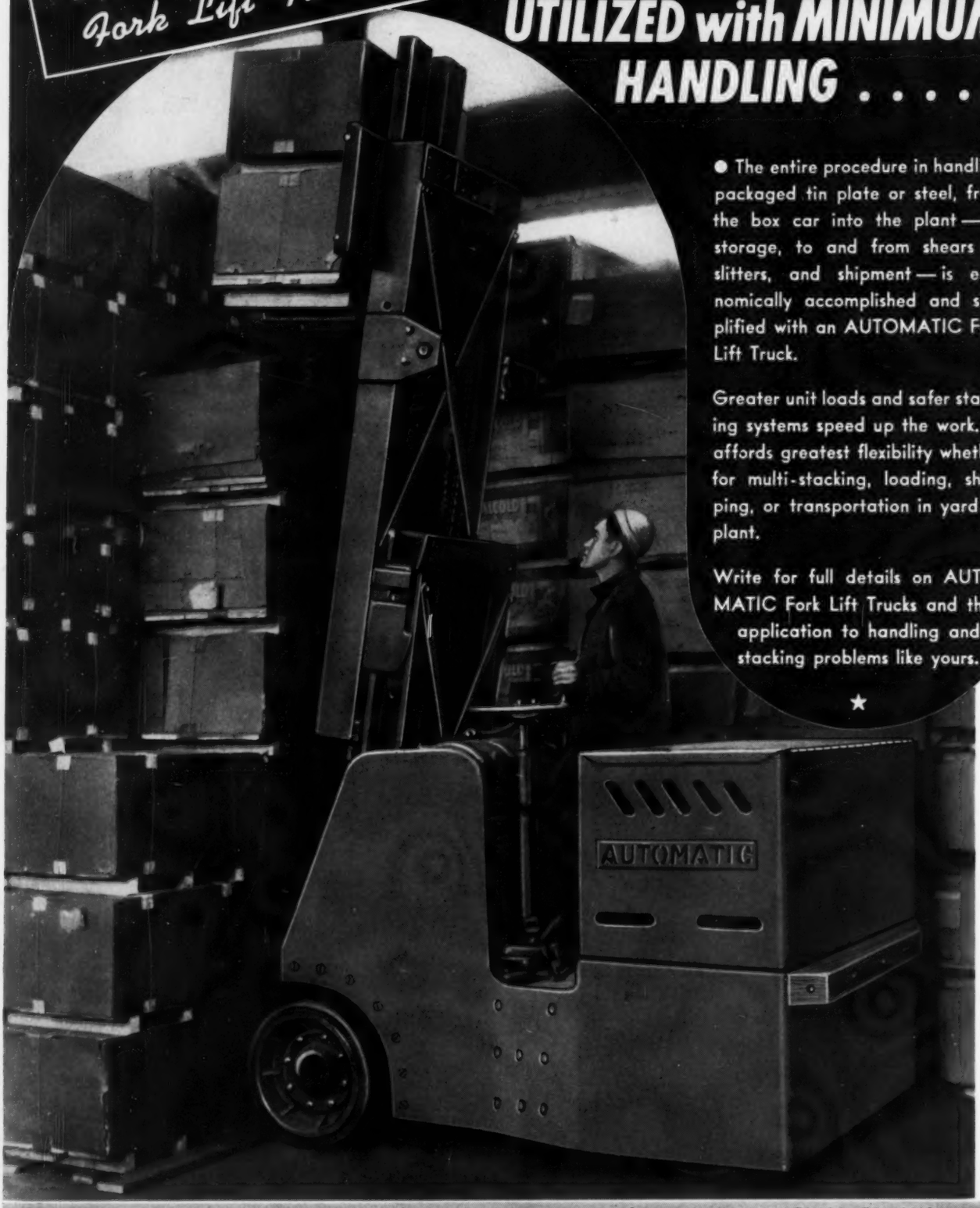
The Bristol Co. of Canada, Ltd.
Toronto, Ontario

THE BRISTOL COMPANY, 123 Bristol Road
WATERBURY 91, CONN.

Bristol's Instrument Co., Ltd.
London, N. W. 10, England

TRADE AUTOMATIC MARK
Fork Lift Trucks

OVERHEAD SPACE FULLY UTILIZED with MINIMUM HANDLING . . . . .



● The entire procedure in handling packaged tin plate or steel, from the box car into the plant — to storage, to and from shears or slitters, and shipment — is economically accomplished and simplified with an AUTOMATIC Fork Lift Truck.

Greater unit loads and safer stacking systems speed up the work. It affords greatest flexibility whether for multi-stacking, loading, shipping, or transportation in yard or plant.

Write for full details on AUTOMATIC Fork Lift Trucks and their application to handling and stacking problems like yours.

★

MANUFACTURERS FOR OVER THIRTY FIVE YEARS *Electric Propelled* INDUSTRIAL TRUCKS

AUTOMATIC TRANSPORTATION CO.

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Iron and Steel ENGINEER

APRIL 1944 — VOL. XXI NO. IV

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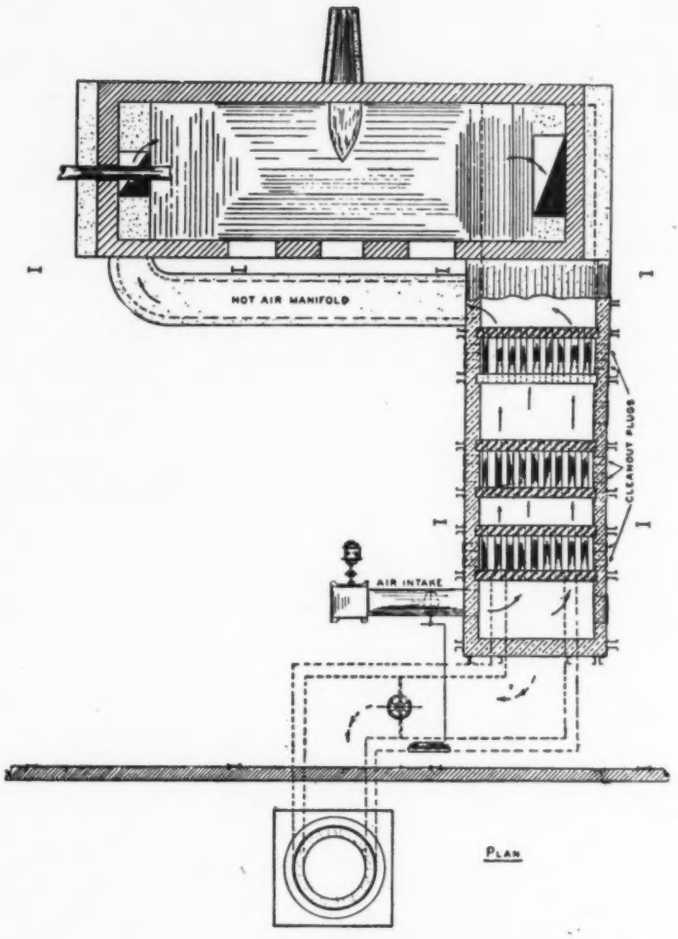
PLASTIC BINDING U. S. PATENT NO. 1178511 LICENSE NO. 18

"FITCH" RECUPERATORS for OPEN HEARTH

The maximum production of a furnace is made possible by firing in one direction continuously. It is not necessary to reverse the flame in relatively small capacity furnaces equipped with a "Fitch" recuperator.

The design illustrated shows a standard small capacity regenerative open hearth furnace converted to a non-reversing recuperative furnace.



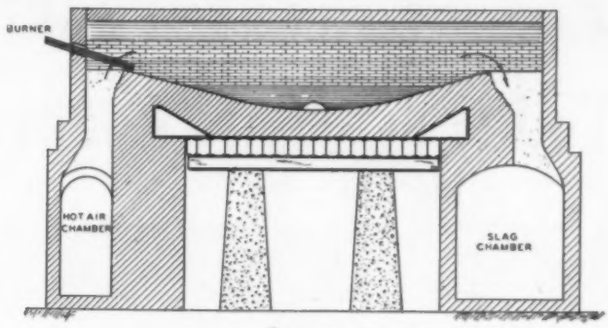
The "Fitch" silicon carbide tubular heat transfer elements will withstand any temperature or chemical reaction found in open hearth practice. Their life is greater than any known material used for this work.

The life of the "Fitch" recuperator as a whole is prolonged over an indefinite period of time by the ability to replace individual parts without disturbing the balance of the structure. Cost of replacements, per ton of steel poured, is negligible.

The first cost of the recuperator is no greater than the cost of the conventional regenerators and reversing valve equipment.

FITCH RECUPERATOR COMPANY

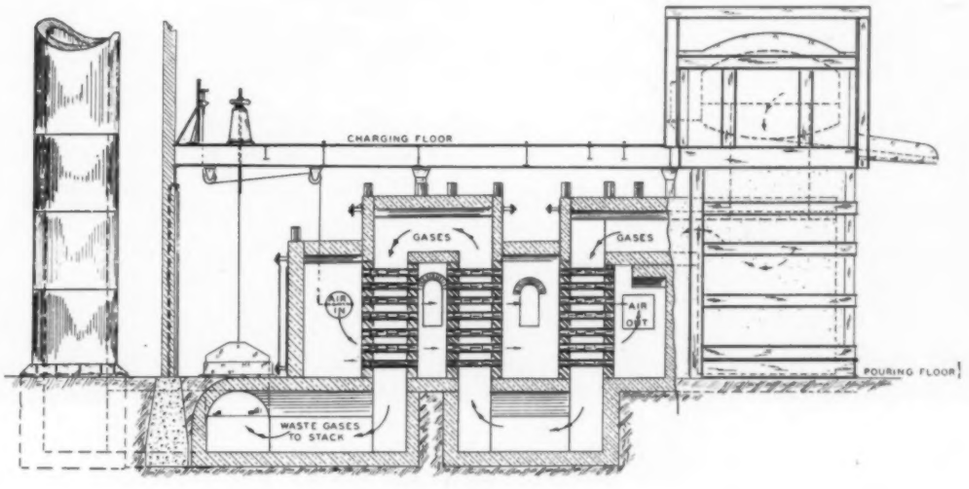
PLAINFIELD NATIONAL BANK BLDG. PLAINFIELD, NEW JERSEY



ELEVATION

The furnace design is not changed other than the remodeling of one slag chamber to form the hot air uptake.

The existing hot air port from the slag pocket level to the burner remains unchanged, utilizing the heat in the furnace brickwork to further increase the temperature of the air leaving the recuperator.



ELEVATION & SECTION

The air for combustion enters the furnace with the fuel in the conventional manner. Air passages cannot clog up as they are used for the passage of air only.

Firing continuously in one direction is ideal for control by instruments.

Write for Bulletin No. 12

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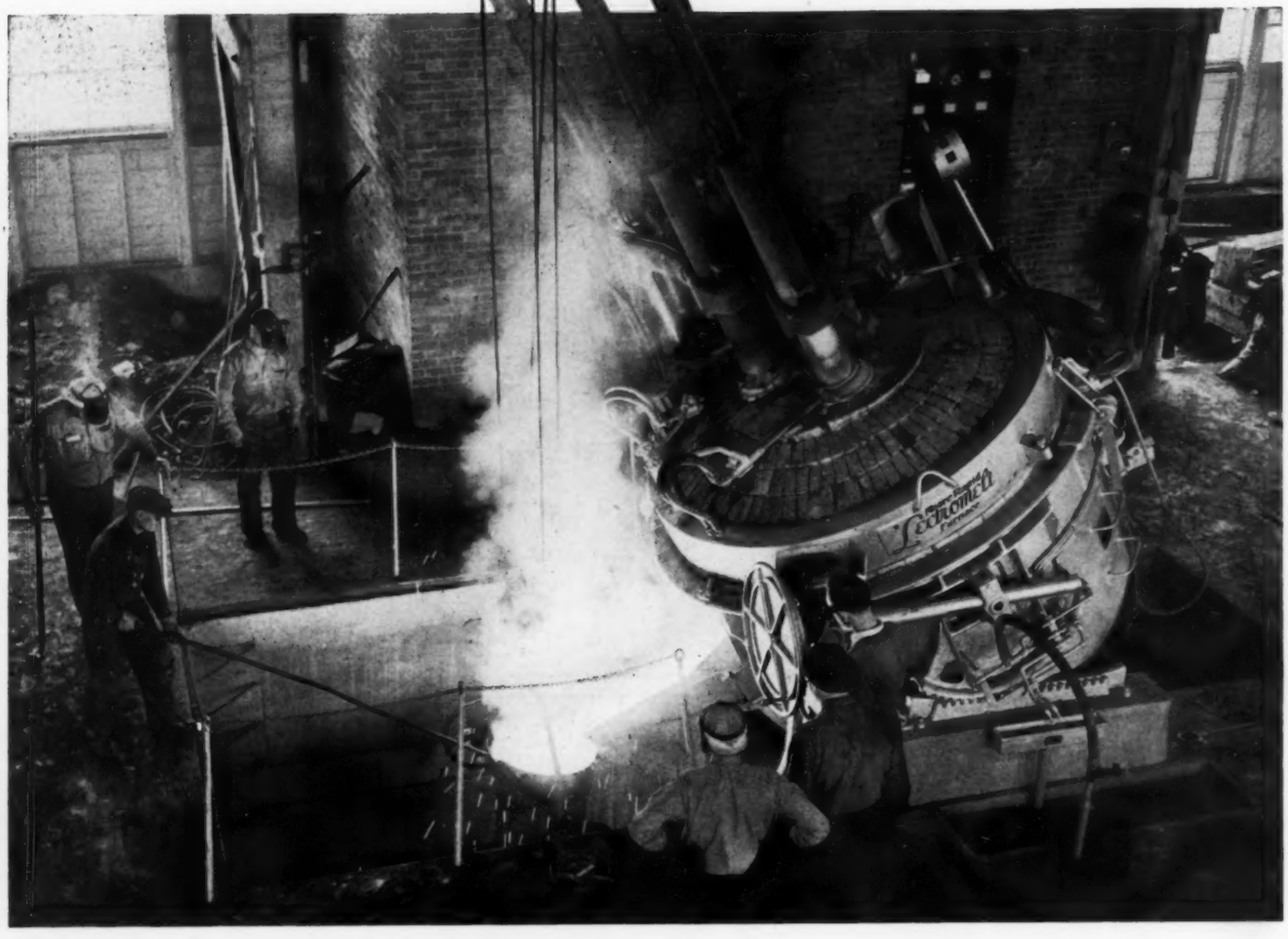

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THE FURNACE OF TODAY AND TOMORROW

Blowing Rates OF VARIOUS Blast Furnaces

. . . . investigation of furnace data shows the relation between blast volume and stockline area to be practically constant over the entire range of furnace sizes, while the more commonly used relation between blast volume and hearth area varies widely . . . .

by E. L. Clair, VICE PRESIDENT
INTERLAKE IRON CORPORATION
CLEVELAND, OHIO

▲ THE need for maximum pig iron production during the present war emergency has called attention to the need for producing the maximum possible tonnage from existing furnace stacks. Another way of expressing this same thought is to say that existing furnaces should be blown with the maximum possible wind volume that can be used without producing conditions which will defeat the purpose.

The question of just what this optimum maximum blowing rate is, and how it may be measured is the purpose of this paper. The subject has been discussed at length by many of the leading operators and blast furnace designers in the past year or two, and several empirical formulae have been presented that in effect propose an answer. In order to evaluate the importance of this matter, it is well to review very briefly the furnace process, and to call attention to fundamental changes in furnace proportions that have been brought about by the development of the modern large furnace.

The blast furnace is in its simplest elements a shaft furnace in which ore, coke and flux stone of the proper physical and chemical characteristics are entered into the top of the shaft. The combustion of coke and the liquefaction and gasification of the charge cause the stock column to move down through the shaft. The air for combustion, preheated in its passage through the stoves, enters at the tuyere level at the lower end of the shaft and reacts with the coke to form carbon monoxide which passes up through the stock performing the work of reduction.

Assuming the proper qualities of the materials charged, and its proper placement in the furnace top, the tonnage of iron that will be produced is measured directly by the wind volume that is used. In other words the productive capacity of any furnace, all other things being equal, is measured by its ability to burn coke. As practically every yardstick regarding this question measures the desirable wind volume in terms of furnace dimensions, particularly working volume, it is in order to call attention to the change in relative furnace proportions that have come about with the development of furnace size and consequent capacity.

The historic development of the apparatus is an interesting study, but in detail it is beyond the purpose of this outline. Far greater progress has been made in the past fifty years than in many hundreds of years before that time. By 1915 the design of the furnace had become fairly well standardized, and a very close approach to the overall proportions of today had been reached. Hermann Brassert read a paper before the American Iron and Steel Institute in May of 1914 where he discussed American blast furnace practice, and showed the development of furnace lines leading up to

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 28-30, 1943

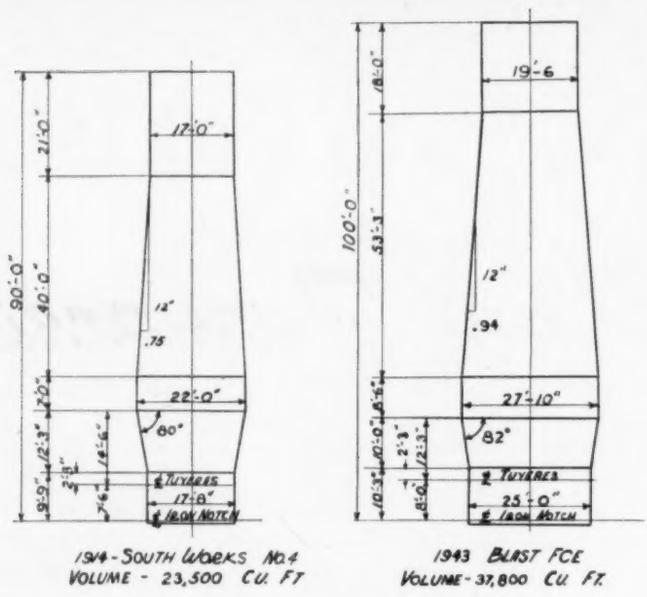

Figure 1 — Sketches comparing lines of a modern furnace with those of an old unit.

South Works No. 4 built in 1914. This represented the best development of furnace lines at that time.

Since that year no outstanding change in furnace lines has been made, except the changes in proportions that were unavoidable with constantly increasing hearth size. In Figure 1 the 1914 furnace referred to and, to the same scale, the modern 25 ft hearth furnace are shown.

The important furnace dimensions are as follows:

	1914	1943
Hearth diameter, ft-in	17-8	25-0
Mantle diameter, ft-in	22-0	27-10
Bosh height, ft-in	12-3	10-0
Bosh angle, degrees	80	82
Total furnace height, ft	90	100
Stock line diameter, ft-in	17-0	19-6
Inwall batter, inches in 12	.75	.94
Total furnace volume, cu ft	23500	37800
Ratio of stock line to hearth	.92	.61

Various yardsticks have been suggested to measure the probable coke burning capacity of a blast furnace. Sweetser suggests a figure of 60 lb of coke per cu ft of working furnace volume per 24 hours as a unit of measure. Some years ago the Bureau of Mines studied some fourteen southern furnaces and suggested a rate of 3.28 lb per min per sq ft of hearth area. Using this latter figure to compare the probable coke rates of the two representative furnaces given above we find the following:

	1914	1943
Hearth diameter, ft-in	17-8	25-0
Hearth area, sq ft	245.1	491
Coke burned per min, lb	804	1610
Theoretical wind volume	44200	88500

As a matter of record, the small furnace did operate on about the wind volume shown, but few 25 ft furnaces of today exceed 70,000 cu ft of wind per min, and if they do the resulting dust loss is unsatisfactory.

Another commonly used yardstick to measure blowing rate is by the volume blown per unit of hearth area. With the small furnaces of the past a volume which equaled 180 cfm per sq ft of hearth area was considered the reasonable maximum. With the large furnace of today this blowing rate per unit of hearth area cannot

TABLE I — Summary of Wind Volumes

Furnace	Hearth diameter, ft-in.	Stockline diameter, ft-in.	Working volume,* cu ft	Hearth area, sq ft	Stockline area, sq ft	Wind volume, cfm	Cfm of wind per sq ft of hearth	Cfm of wind per sq ft of stockline	Cfm of wind per 100 cu ft of volume
1	12-7½	11-6	9,410	125.2	103.9	23,000	184	221	244
2	15-7	14-0	15,600	190.7	153.9	34,000	178	221	218
3	17-3	14-9	15,980	233.7	170.9	39,000	167	228	244
4	18-0	16-0	21,220	254.5	201.1	42,225	166	210	199
5	19-0	16-4	21,690	283.5	209.5	46,000	162	220	212
6	19-0	18-0	27,300	283.5	254.5	52,651	185	207	193
7	20-0	17-6	25,880	314.2	240.5	56,033	178	233	216
8	20-0	17-6	25,900	314.2	240.5	57,470	182	239	222
9	20-0	17-0	26,500	314.2	227.0	54,298	173	239	205
10	20-9	18-0	26,060	338.2	254.5	54,000	160	212	207
11	21-0	17-0	27,800	346.4	227.0	50,000	144	220	180
12	21-6	18-6	28,490	363.1	268.8	56,381	155	210	198
13	22-0	18-6	33,170	380.1	268.8	55,300	145	206	167
14	23-0	19-0	33,930	415.5	283.5	62,435	150	220	184
15	25-0	19-6	37,970	490.9	298.7	67,696	138	226	178
16	25-0	19-6	38,680	490.9	298.7	68,005	139	228	176
17	27-0	19-6	45,060	572.6	298.7	79,318	138	265	176
18	27-3	20-0	43,860	583.2	314.2	75,900	130	241	173
19	28-6	19-0	40,770	637.9	283.5	77,656	122	274	190

*Working volume is assumed to be from center line of tuyeres to 2 ft below large bell closed.

be maintained, and with continued increase in hearth diameters it has been necessary to decrease this rate to about 130 cfm per sq ft of hearth area.

The correct wind volume for any given furnace, or for any group of furnaces will be affected by other items than furnace design. The type of metallic charge, quality of fuel, both physical and chemical, condition of the lining, and the grade of iron being produced are among the principal factors other than furnace design which will affect the matter.

Wind volumes varying from 180 cfm per sq ft of hearth area to 60 cfm are used successfully. There is probably no reasonable limit to the wind volume that can be successfully used insofar as thermal or metallurgical action in the hearth or bosh of the furnace is concerned. Since such widely varying rates are used it is probable that the limiting factors are the gas velocities obtaining in the shaft of the furnace, and particularly at the top of the shaft, and the pressure drop through the furnace. The gas velocity at the stock line, all other conditions being the same, determines the amount of dust that will be produced. Excessive pressure, or rather excessive pressure drop through the furnace, even assuming that it does not immediately affect the furnace movement, eventually will cause an abnormal wear on the furnace lining.

The writer is associated with an iron producer operating six furnaces varying in hearth size from 12 ft-7½ in. to 21 ft-0 in. Observation of the operation of these stacks indicates immediately that per unit of size the smaller furnaces produce a much greater tonnage of iron. This of course is for the obvious reason that the operators are able to blow proportionately higher wind volumes on the smaller units. In trying to evaluate this increase in blowing rate on the small units, or more correctly the decrease in blowing rate on the larger units, the data assembled by A. G. McKee in his study of this matter was examined. In all, the operating records of nineteen furnaces were checked and the conclusions arrived at are based on that data.

It appears that in the development of furnace design and practice, progress has been made by the method of trial and error, rather than by any precise development of any academic concept of the process. In other words, one can take the operating records of any furnace with reasonable safety, as the probable maximum that the furnace will handle. The operator will blow the furnace just as hard as he can without getting into trouble, dependent upon his materials, furnace condition, design, etc. Accordingly, we have assumed the wind volumes shown as representative of the maximum, with reasonable dust losses and good operation.

Nineteen furnaces are shown (Table I), of which six are on merchant grades, and the balance on steel mill iron, at least the greater part of the time. It will be noted that the furnaces are listed in the order of hearth size, and then using the actual published wind volume. The blowing rate in cfm per sq ft of hearth area, and of stock line area, and furnace working volume are calculated. The working volume is assumed to be from the center line of the tuyeres to a point 2 ft below the bell closed.

The results of the calculations were then plotted against hearth diameter (Figure 2). While it is immediately apparent that precisely regular increments will not develop, because practically no two furnaces are alike on the entire sheet, this method was used to show definite trends if they were present.

An examination of the graph shows three things.

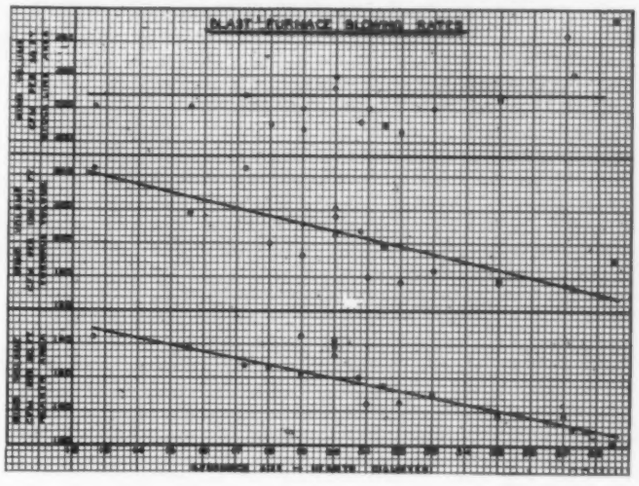

Figure 2 — Graph showing blast volume in relation to hearth area, furnace volume and stock line area for various sizes of furnaces.

First there is an almost regular decrease in the unit volume of wind blown with increase in hearth size. Very small furnaces are blown with 165 to 180 cfm of wind per sq ft of hearth area. Very large furnaces are blown at the rate of 130 to 140 cfm of wind per sq ft of hearth area. In the case of the wind volume per 100 cu ft of working furnace volume there exists very wide variations, but at least for the furnaces investigated the practice seems to be the same as when measured by hearth size. Small furnaces are successfully operated with wind volumes up to 240 cfm per 100 cu ft of furnace volume. With large furnaces the volume is reduced to 175 to 190 cfm per 100 cu ft of volume.

In the last case, that is, the blowing rate per unit of stock line area, there seems to be no relation between furnace size and wind volume. Fifteen of the nineteen furnaces have a blowing rate per sq ft of stock line area between 210 and 240 cfm, and the larger furnaces are as a rule not greater or less than the small furnaces. The average rate of all furnaces checked is 227 cfm per sq ft of stock line area.

This seems to indicate that the limiting dimension is the diameter of the stock line, that is, assuming that in all furnace dimensions a reasonable approach to good design is followed. And this is not an unreasonable conclusion for it simply states that the gas velocities existing at the top of the column reach a practical desirable maximum when approximately 230 cfm per sq ft of top area is blown.

This observed fact may be expressed as a simple empirical formula for wind rate and coke weight burned per day.

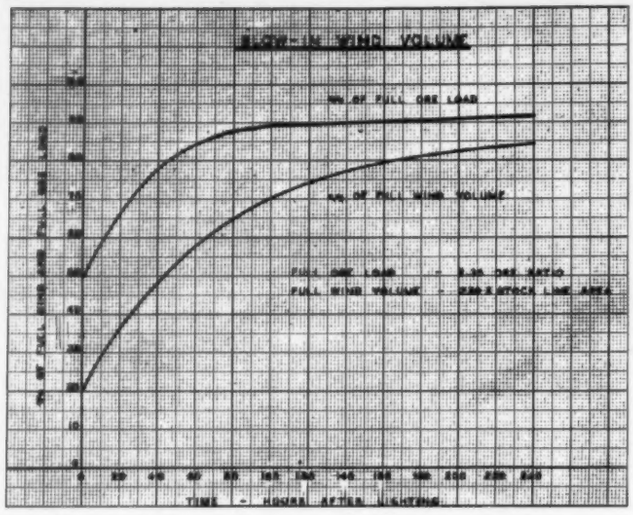

Figure 3 — Curves showing burden and wind schedule for blowing in.

Wind, cfm at 60 F = 230 x top area, sq ft

Coke burned per day = 6000 x top area, sq ft

In the case of several furnaces the wind volume being used was checked as above and found to be less than it was indicated should be blown. The increase indicated was made with a direct increase in the weight of coke burned and no increase in dust loss.

Overall, if the foregoing has any value it lies in directing attention to the importance of this matter of top design. It is realized that furnace top diameters in excess of 20 ft have not been tried and would perhaps result in difficulties with stock distribution that would offset the advantage of the reduction in gas velocity. However, it seems that some answer will have to be found if the best possibilities of large furnaces are to be realized.

In regard to this matter of blast furnace production the maximum normal capacity is often stated to be 2.45 net tons per sq ft of hearth per day. Many furnaces exceed that figure today, but it is interesting to note that the production measured with reference to hearth size increases as the furnace size decreases. On our six furnaces, all producing merchant iron with silicons largely from 2.00 per cent to 3.00 per cent, we note the following:

Furnace	*Hearth diameter, ft-in.*	*Net tons per sq ft of hearth per day*
1	12-7½	3.10
2	15-7	2.65
3	17-3	2.51
4	19-0	2.37
5	20-9	2.32
6	21-0	2.29

In connection with the question of the proper wind volume for a blast furnace, there is considerable difference of opinion regarding the proper wind schedule in blowing in a furnace. We have kept detailed records of this phase of the operation for some time past, and the graph shown as Figure 3 represents our most satisfactory experience as regards blast schedule, referred to ore load and time of lighting. The schedule shown may seem pretty fast, but it has been used with complete satisfaction, and has avoided the troublesome high top heats that are frequently encountered.

In conclusion might I say that the best definition of blast furnace capacity I ever heard was simply "what you can get out of them." The brief record which I have given you only relates what results some operators have obtained from their furnaces.

DISCUSSION

PRESENTED BY

H. E. McDONNELL, Superintendent, Blast Furnace and Coke Plant, Weirton Steel Company, Weirton, West Virginia

J. S. FULTON, Special Representative, Ingersoll-Rand Company, Pittsburgh, Pennsylvania

H. E. McDonnell: In the efforts to increase the production of pig iron without additional equipment, too much stress cannot be placed on the large returns that uniformity will yield in the modern fast driving blast furnace. Starting as far back as the face of the coal in the mine, blending of coals and the later mixing and bedding of coals preparatory to charging into the coke ovens pays dividends in promoting coke uniformity. Careful grading and mixing of ores is conceded as of prime importance and the uniform operation of the furnace must be given a place of as much importance as the uniformity of raw materials.

A properly equipped and operated blast furnace can be heavily burdened and blown for maximum pig iron production when materials are constantly uniform. A recurring irregularity in raw materials makes it necessary to operate a blast furnace on the safe side in order to maintain iron quality and smoothness of operation, and the safe side means a decrease in blast furnace production.

J. S. Fulton: I have a couple of items to add to the discussion that have to do with the mechanics of getting the blast volume away from the blower and to the method of signaling between the furnace and blowing room.

Considerably larger blast volumes are being ordered than were customary just a few years ago. Very many furnace men think only in terms of volume of blast and few ever think back to the fact that blast volume, blast pressure, and rpm all are tied together in particular ratios for each turbo-blower. Still fewer appreciate that, in effect, the air drawn into the blower must be pushed out of the top of the furnace against all resistances encountered up to that point and against the back pressure in the top gas main. Consequently when

the setting of the constant volume governor is increased the rpm must be increased not only for the new volume inhaled but must be further increased in order to maintain at the beginning of the cold blast line the higher blast pressure required to push this greater volume out of the top of the furnace.

It can be seen that if no orifice exists in the discharge system no air can be inhaled by the blower, and that if the furnace voids provide only a moderate orifice area, the first result from an increased volume delivery is an immediate increase in blast pressure. Therefore, when the furnace man orders an increase in blast volume the particular rating of the blower will only permit the delivery of this volume through an adequate orifice in the furnace. This all boils down to the statement that the slighter the rate of change in the order for blast volume, the lesser the increase in blast pressure and the lesser the chance of upsetting the orderly travel of the blast through the furnace.

The next matter I want to touch upon is a modification of the conventional signaling system between the furnace platform and the blowing engine room. Every system I have seen is laid out on the basis that it is more important for the furnace crew to be able to dictate temporary changes in the blast volume order, in order to protect the furnace, than it is for the engine room crew to dictate similar temporary changes in order to protect the blowing unit. The conventional system has been satisfactory for years, but since all of the turbo-blowers are getting older and are carrying much higher loads than when first installed it is reasonable to anticipate more mechanical troubles that may require a temporary decrease in the volume order or might even require getting another unit on and this unit off the line. At present the only way the engine room crew has of notifying the furnace man is by telephone, with more or less delay, but by rearranging the present signal system so the engineer could push a button sounding a signal at the furnace a given number of times corresponding to his needs, the furnace would be benefited in the long run.

As an illustration of the mess that could be avoided by such a reverse signal I will outline what recently occurred to one turbo-blower. The unit had been blowing slack wind for several hours and immediately after going onto the full volume, smoke began to come up around the machine. This came from lubricating oil spraying from a cracked auxiliary line catching fire from contact with a superheated steam line below the floor. While one man tried to phone the furnace the balance of the crew nursed a cold unit onto this cold blast line. The minutes required for this allowed the fire to make such headway that when the crew returned to the first unit, the flames prevented them getting to the regular throttle valve and the unit continued to feed oil to the fire until shut down by a steam valve outside of the building.

Very fortunately little damage was done to the unit itself but its use was lost for over two weeks until the control panel which had been gutted could be rebuilt, but practically all of this could have been saved if, after the reverse signal had been given, the crew could have devoted themselves to the fire.

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PLANT *Distribution Systems* FOR OXYGEN AND ACETYLENE

. . . . so widely has the use of oxygen and acetylene been adopted in the production of iron and steel that practically every plant has gone to distribution systems serving large, permanent consumptions from central points . . . .

by Herman Ullmer

MANAGER, PROCESS SERVICE

THE LINDE AIR PRODUCTS COMPANY

NEW YORK, NEW YORK

▲ IN view of the facility with which the oxy-acetylene process of cutting, heating and welding metals can be adapted to many of the production and maintenance operations occurring in steel plants, it is not surprising that this process is used extensively in practically all departments. This extensive use of oxy-acetylene processes in the steel plant demands an efficient method of supplying the oxygen and acetylene consumed. While the familiar compressed oxygen and dissolved acetylene cylinders are practical and efficient supply units where the usage is of a temporary nature or of relatively small consumption volume, the limited capacity of such individual containers precludes their use for most of the oxy-acetylene operations in a steel plant, which are both of fixed location and relatively large consumption volume. Such usage is more practicably served by large capacity supply units and piped distribution systems. The purpose of this paper is to discuss the installation and operating features of such systems.

SUPPLY FACILITIES — OXYGEN

Cylinder manifolds — Cylinder manifolds offer a means of supplying oxygen to a distribution piping system. Such installations consist of two headers — operated alternately for providing an uninterrupted supply — by which a number of cylinders are interconnected for their common discharge to the service piping system through a pressure-reducing regulator. Operation of the manifold consists of the manipulation of the header control valves and the replacement of the cylinders after they become empty. While such supply units are a convenient means of supplying oxygen in some cases, their application is limited to service where the amount of usage does not require an excessive stock of cylinders and an objectionable amount of labor for handling them to and from the manifold. In a steel plant, these capacity limitations restrict the use of cylinder manifolds as supply units to operations which are either of a temporary nature, or of limited consumption volume located too far from the main system to warrant the expense of piping the supply from it.

Central supply units — Several systems for handling oxygen in large quantities have been developed by the various oxygen manufacturers as a means of serving the oxygen requirements of a steel plant from a single, centrally located supply unit. In some of these systems, the oxygen is delivered to the steel plant supply unit in the gaseous state; in others, it is delivered in the liquid state. Several types of gaseous systems are em-

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 28-30, 1943

ployed, but the principal feature is that the oxygen is delivered to the plant in a high-pressure, large capacity container unit which, after connection, operates automatically to supply the distribution piping system. To afford an uninterrupted supply, several of these units are kept in service on an alternate operating schedule. In the liquid-oxygen systems, the liquid oxygen is delivered to an insulated storage vessel from which it is withdrawn and gasified previous to its delivery to the distribution piping system.

These bulk-type supply units are admirably suited to the oxygen supply needs of a steel plant because they provide compact, automatically operating installations, with adequate storage and output capacity, that can be kept replenished by relatively few, large-quantity deliveries.

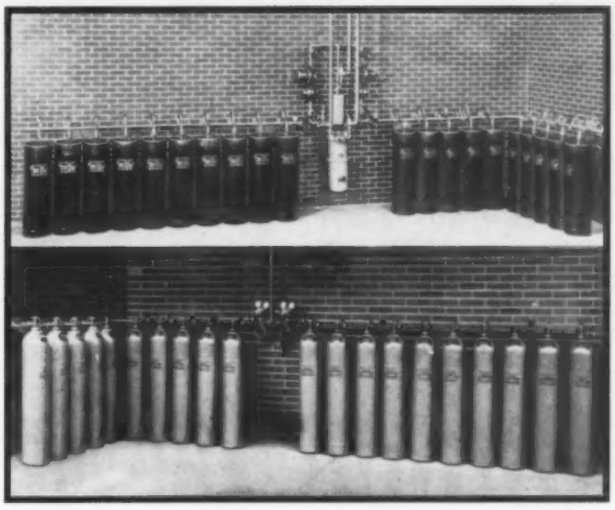


Figure 1 — Views showing wall type cylinder manifolds, with cylinders feeding into headers from which the gases are fed at regulated pressures into the distribution system.

SUPPLY FACILITIES — ACETYLENE

Cylinder manifolds — Acetylene cylinders can be manifolded for supply to a piped distribution system as in the case of oxygen. The general arrangement of the manifolds and their operation is similar to that of oxygen manifolds.

Acetylene manifold installations are adapted for serving usage in areas located at a considerable distance from other usage points. Their application in a steel plant, however, is restricted by the amount of labor required for handling the cylinders. Another limitation is that, for operations requiring a high supply rate, a very large manifold installation is required to restrict the discharge rate per cylinder to that at which the dissolved gas can be discharged satisfactorily.

Acetylene generators — Acetylene generator installations, in which the acetylene is produced from the reaction of calcium carbide and water, are an excellent means for supplying the usage of acetylene in a steel plant. Properly designed, such installations afford compact, dependable production units that can be operated with a relatively small amount of labor to produce acetylene at a much lower cost than that of the dissolved gas in cylinders.

There are two types of acetylene generator installations suitable for service as central supply units in steel plants, one comprising a number of so-called "medium-pressure" generators in which the gas is generated at the required pressure; and the other, a generator-gas holder-booster pump combination, in which the gas is generated at low pressure in a single large-capacity generator and then compressed to required operating pressure by means of rotary compressors.

Figure 2 — Main floor of generator room in a medium pressure acetylene installation. All operations except filling with carbide occur on this floor.

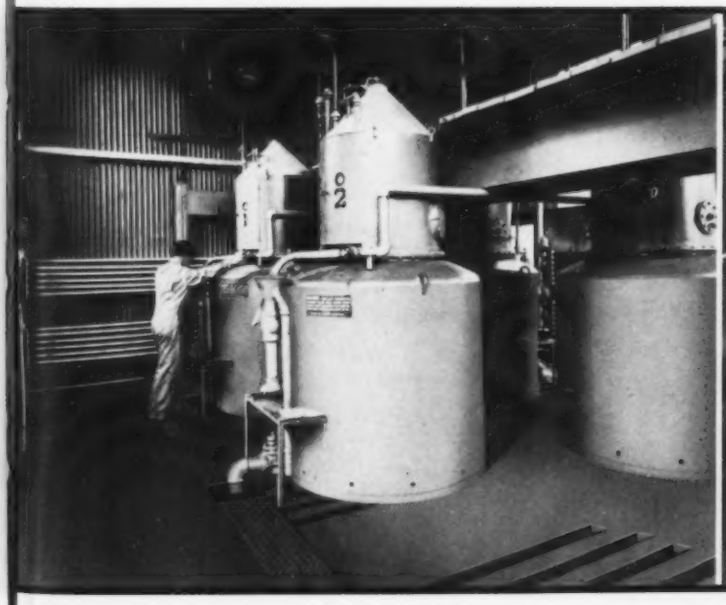
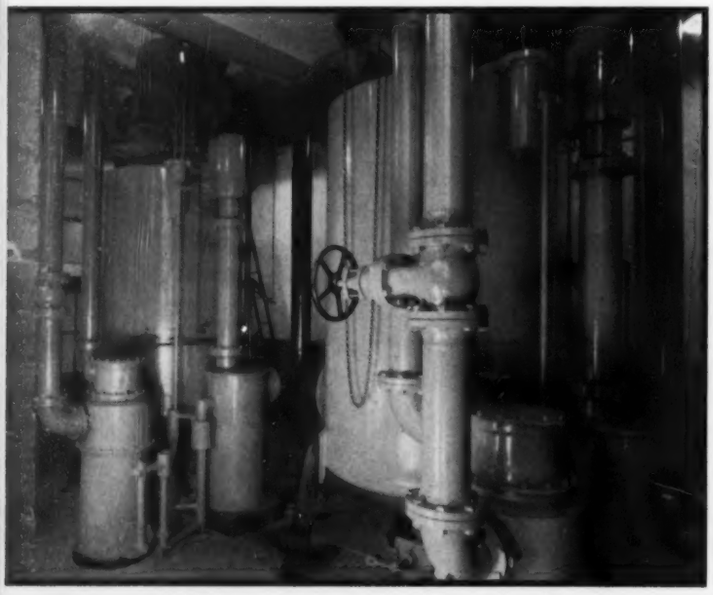


Figure 3 — Carbide is charged into the generators shown in Figure 2 from the charging platform, using a hopper which travels along a monorail.

While the "medium-pressure" type of generator does have the advantage of generating the acetylene at the pressure required for use, it is somewhat restricted in production capacity; that is, the largest size available is one having a carbide capacity of 500 lb and a rated hourly output capacity of 1000 cubic feet. For installations where the consumption load exceeds this capacity, a number of 500 lb generators and an arrangement of output balancing or synchronizing equipment are provided. Such multi-generator installations are in use as central supply units in a number of steel plants. The generators arranged in one or two rows are served with carbide by means of a monorail trolley hoist carrying a specially constructed carbide-charging hopper, which is filled in a carbide storage room adjacent to the generator room. With these provisions of automatic generator-output synchronizing and labor-saving carbide recharging facilities, the multi-unit "medium pressure" generator installation makes a very satisfactory central acetylene supply unit for steel plants.

The low-pressure generator, booster pump installation consists of one or two low-pressure generators, a low-pressure storage holder and a unit of one or more rotary compressors. The generators operate automatically by control afforded by limit switches on the gas holder and the booster pumps are automatically controlled by pressure-actuated switches connected to the service piping system. Carbide charging is effected by means of an elevator equipped with a discharge chute which ends directly over the charging door of the generator. Generators of this type are available in a size which has a 1000 lb carbide capacity and a generating capacity of 6000 cubic feet per hour. In comparison with the multi-unit "medium-pressure" generator installation, the low-pressure generator-booster installation has the advantage of operating with less manual effort and attention, and consequently becomes a more desirable type as the consumption exceeds 3000 or 4000 cubic feet per hour.

Figure 5 — In the low pressure generator-booster installation, generators operate at approximately 6 in. of water pressure. Carbide is fed by a screw driven by a slow speed water motor.



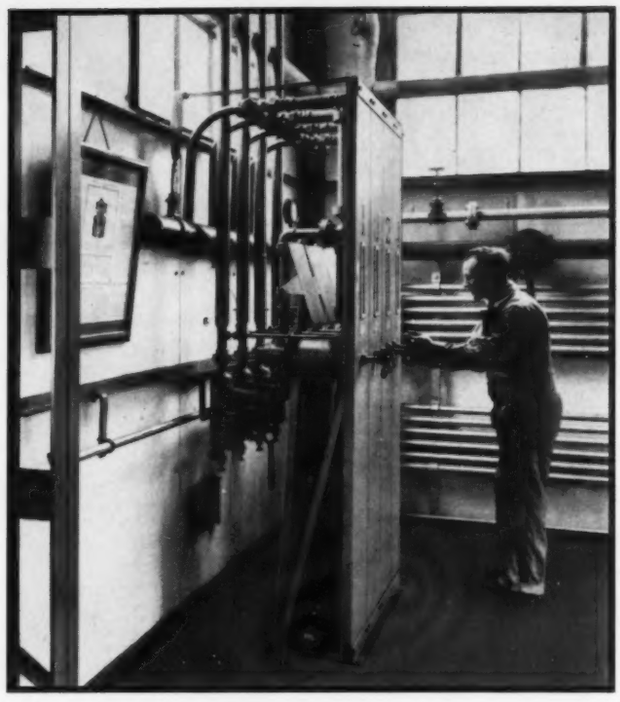


Figure 4 — Control panels for the acetylene generators carry adjustable flow control regulators and indicating flow meters.

GENERAL ASPECTS OF DISTRIBUTION PIPING SYSTEMS

Service coverage — By installing and using distribution piping systems for oxygen and acetylene, a large number of steel plants have demonstrated that all but a relatively small amount of the total usage can be practicably supplied by piped service from a central supply unit. While an economical balance must necessarily be maintained between the benefits of piped service from a central supply unit and the cost of installing the piping required to reach the locations of use, it is generally possible to plan a piping system, which by serving the major points of usage provides a network of supply mains from which relatively inexpensive branch extensions can be made to reach the secondary points of use. As a result, it is generally economically feasible to provide piping systems which will serve 85 to 95 per cent of the total plant usage.

Reliability and safety of piped systems — The operation of oxygen and acetylene-distribution piping systems in a large number of steel plants for the past 10 or 12 years has proved that well-constructed systems of this nature are both reliable and safe. This is undoubtedly a natural result of the conditions involved. With the strength factor available in welded construction, and with the piping properly located in positions where it is not exposed to injury from plant operations,

there is little occasion for accidental breakage of lines or other injuries sufficient to cause interruption of service. The safety feature is similarly the natural result of the distribution of the gases at low pressures in permanently located, safely placed piping, as compared to their use from high-pressure cylinders that can be carelessly located in very exposed positions.

Operating control — The use of a piped supply has the important advantage of minimizing the wasteful and inefficient operating practices associated with the use of excessive working pressures, since the line pressure available for use is subject to central control at the supply unit. Such pressure control is more important with oxygen because the use of excessive acetylene pressures is opposed by the adverse action of the flame produced. In oxygen-piping systems, the common practice is to carry a line pressure sufficient for the heaviest class of work commonly occurring, and then obtain separate pressure control for lower-pressure operations by means of branch-line pressure control stations where a group of identical operations are carried out, or by means of individual station outlet regulators where a varied class of work is performed.

Metering and other methods of allocating total usage — Two methods are employed satisfactorily for the accounting of the quantities of oxygen and acetylene supplied to the separate departments of a plant served by a single distribution piping system: direct measurement by meters, or allocation based on the respective amounts of oxy-acetylene consuming work occurring in each department. Except that special construction providing for the use of materials resistant to combustion in oxygen, and cleanness from oil, grease, and similar materials are essential; both the positive-displacement, bellows-type of meter, and most of the various patterns of orifice-type meters used for metering steam, compressed air or other gases can be used satisfactorily for metering oxygen. Bellows- and orifice-type meters can also be used for metering acetylene, provided that no parts that come in contact with the acetylene are composed of unalloyed copper, and that where bellows-type meters are employed, a hydraulic back-pressure valve is installed immediately following the meter.

Various methods of allocating the usage by figuring the consumption from the oxy-acetylene consuming production operations of the departments concerned have been employed satisfactorily. Average consumptions per ton of steel processed, as determined from previous records of cylinder gas usage, or as calculated from blowpipe consumption rate and operating time, can be used as unit factors for application to the tonnage output for determining the usage in processing mills, melting furnace departments, scarfing docks, scrap-cutting yards, and similar areas, where the work is of a uniform nature and where the tonnage values are readily obtainable. For fabricating or maintenance shops, where a varied class of work is conducted, records or estimates of the blowpipe hours for each class of operation may be necessary to arrive at a more accurate, calculated shop consumption.

DESIGN OF DISTRIBUTION PIPING SYSTEMS

While the general problem is that of piping gases under relatively low pressures, the piping of oxygen and acetylene is special in several respects. Proper design requires a well-founded knowledge of the operating requirements of the equipment involved, that is, its consumption rate, operating pressure, sensitivity to pressure variation, etc.; and an understanding of the mill premises and operating conditions in order to provide service arrangements that will be both convenient and practical.

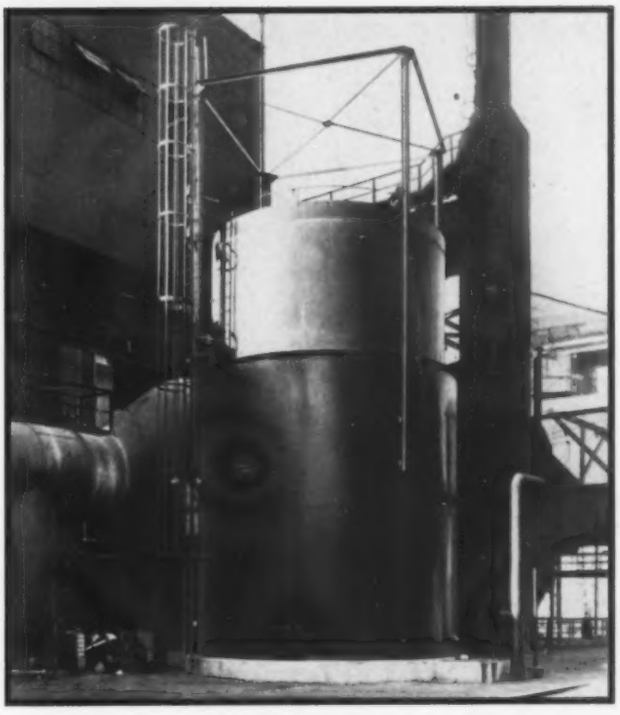


Figure 6 — Low pressure gas storage holder, of 5000 cu ft capacity, on acetylene system. Limit switches on the holder control the feed of carbide to generators and act to stop booster pump motors if the holder falls to the low limit.

In view of this scope and rather complicated nature of the problem, we have found it impractical to prepare any treatise or manual covering all phases of the design of oxygen and acetylene-distribution piping systems in plants as extensive and varied as steel plants. Our designs are based on actual surveys of the premises by trained personnel intimately familiar with oxy-acetylene equipment and its use in steel plants. These surveys include a thorough discussion of the intended installation and its operating features with all mill operating personnel who are concerned with the oxy-acetylene operations to be served, or with the servicing of the system as a piped facility. While we believe the design of oxygen- and acetylene-distribution piping systems is best handled on this basis, we wish to cover the major features which influence or determine the design of piped oxygen and acetylene systems.

Design factors — The most important factors to be considered in design of oxygen- and acetylene-distribution piping systems are: (1) the location of the supply unit; (2) the extent to which it is desirable to provide piped service; (3) the selection of the best arrangement for interconnecting the individual runs of piping; (4) the location of outlet stations, and the placing of the

piping and station outlets for avoiding exposure to damage from mill operations; (5) the investigating and analysis of the number and nature of the operations to be served for determining the flow loads to be provided for; (6) pressure control, flashback arresting, and outlet station equipment; (7) the sectionalizing of the piping for size reduction where the flow load is reduced, the apportionment of flow load pressure drop, and the calculation of pipe sizes; (8) the use of receivers or alternate methods of supplying the oxygen requirements at a high rate of flow.

The location of the supply unit should be central with respect to the consumption loads, in order to minimize the size of service piping mains, convenient to motor truck loads and railroad sidings for deliveries of replacement stocks; and at a safe distance from buildings, operations, or facilities that could accidentally constitute a hazard to the oxygen or acetylene storage or operating equipment.

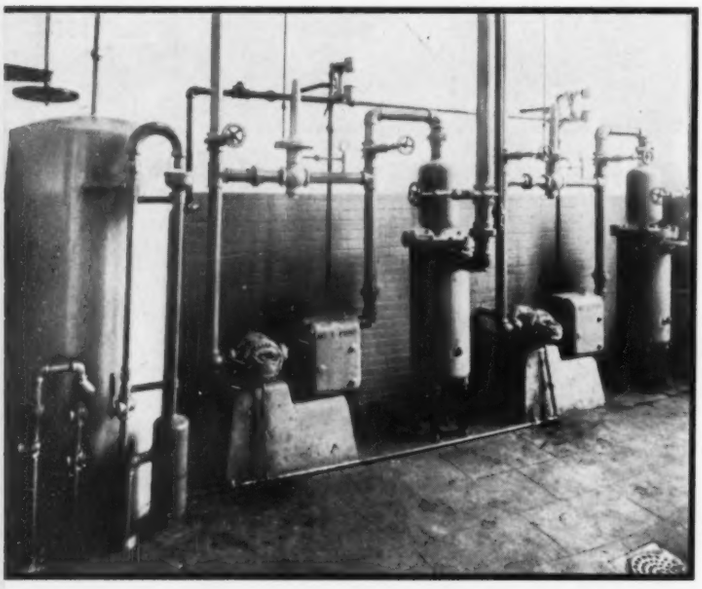


Figure 7 — Booster pumps are water sealed, rotary type. Hydraulic back pressure valves are shown to the right of each pump. The large tank at the left is for cooling the pump sealing water.

The choice of usage locations to which it is desirable to provide piped service depends on the volume consumption at each of the operating locations involved, the comparative benefits of providing piped service, and the expense of installing the piping needed. Where a complete, new installation is involved, an accurate but comparatively simple solution can be attained by planning a piping system complete enough to reach all usage that could be supplied through piping, and then deciding the case of all questionable usage areas by comparing the relative cost of the piping required to serve the area in question with the relative amount of the total plant usage which will be used in that area.

The most desirable arrangement for interconnecting the various runs of piping is one that provides a system of mains radiating from the supply unit, from which service to the group of outlet stations in each usage area is supplied through a separate lateral branch line. The advantage of such an arrangement is that service to any lateral branch can be shut off by closing a "section shutoff" valve installed at the inlet end of that branch without affecting service through the rest of the system. Such independent shutoff is a decided convenience in effecting repairs to station outlet valves, or in altering or extending the run of a branch line. In the case of acetylene piping systems, this arrangement permits a most effective location of line-type hydraulic back-pressure valves, that is, at the entrance end of all branch lines which carry outlet stations, where they will serve to check any flashback not arrested at the station outlet and so prevent it from affecting service to any other part of the system.

The location of station outlets is determined by the type of oxy-acetylene operation and the working conditions in the vicinity. Wherever possible, outlet stations should be located on building walls or building columns, as such locations generally offer the best protection from damage from mill or shop operations. Where such location is not practical, as in the case of certain scarfing docks at which the building or craneway columns are located at a considerable distance from the operator's work, the station drop piping may be extended underground from the building column to provide an outlet housed in a low, above-ground guard structure located in the center of the bay.

A thorough investigation of the number and nature of the oxy-acetylene operations to be served is necessary to develop the data required to determine the piping flow loads to be provided for. This information is best obtained by checking the operations conducted in each usage area with the foreman or other supervisor in direct charge of the operators concerned. Where the operations are of a production or established routine nature, such as those at scarfing docks, or at open hearth furnace departments, the consumption per equipment unit and the maximum rate of consumption for the entire group of operators are quite easily evaluated. However, determining the maximum total rate of consumption likely to occur at any instant is more difficult where the work is cutting and welding of a wide range of material thickness, conducted by a group of workmen who use their equipment on an irregular, intermittent schedule. A careful evaluation of the frequency of occurrence of each class of work and of the "on" time per outfit is required in such instances.

On oxygen-distribution piping systems, the method of pressure control employed depends on the nature of the operations to be served. For separately located operations, or for a group of stations at which the work involves use of various pressures, the necessary independent pressure regulation is obtained by the use of individual, station-type pressure regulators. For permanently located oxy-acetylene machines, or other equipment used frequently at the same location, this station pressure-regulating equipment can be provided as a fixed assembly; but for occasional use, the stations are equipped with outlet valves having regulator connection outlets, and a small-size, detachable type regulator is furnished each operator as part of this equipment outfit for connection to an outlet valve on the station nearest the job involved. Where the service is to supply a group of operators engaged in blowpipe work of the same nature, such as a group of scarfers at a billet or

slabyard, a common pressure control is provided by installing a separate branch line for the group of outlet stations used, in which the line pressure is controlled by means of a branch-line pressure-control station installed at the inlet end.

Two types of equipment are employed as outlet devices on acetylene distribution piping systems in steel plants: station type pressure regulators and hydraulic back pressure valves. The station-type pressure regulator is the spring-loaded diaphragm-type of instrument commonly used for pressure-reducing purposes. The hydraulic back-pressure valve is a flash-arresting device consisting of a check valve submerged under a seal of water in a chamber which is fitted with a pressure-relief valve. In functioning, the water seal and check valve arrest the flashback, and the relief valve opens to release the back pressure through a vent line extending to out-of-doors. The pressure regulator arrangement is employed at stations supplying operations such as welding, precision-cutting and flame-hardening where variation in the flame adjustment is an important factor in affecting the quality of the work. The hydraulic back-pressure valve is used at stations supplying operations such as scrap-cutting and scarfing where a regulated flow control is not essential, but where the working conditions make a more positive flashback-arresting device desirable.

The service or outlet valves used on oxygen and acetylene distribution piping systems are a type especially designed for the purpose. The packingless, diaphragm design and heavy, pressure-forged body used on these valves minimize opportunities for body leakage. The outlets, which are an integral part of the valve body, are threaded to match the special threads standard for oxy-acetylene equipment connection fittings to prevent the attachment of improper equipment.

The valves are provided with an outlet plug assembly, chained to the valve to furnish a supplementary leak-preventing seal when the valve is not in service. Lubricated plug cock-type valves are used for acetylene line shutoff valve service, and for shutoff valves at hydraulic back-pressure valve stations. Globe-type valves are used for branch line or "section" shutoff valves on oxygen piping systems.

Separators, or suitable arrangements for removing the scale and dirt originating in the piping, are required ahead of outlet valves and branch line regulators on oxygen piping systems, to prevent this "foreign" material from injuring the working parts of the valve or regulator, or obstructing the orifices in the torch equipment. This "foreign" material is largely small particles of the scale formed in welding the pipe joints, and other foreign solids accidentally introduced into the pipe during its handling and erection. The type of device employed depends largely on the equipment and operation involved. For line pressure regulators, or for operations such as flame-hardening, where the clogging of the small-diameter flame tips by a few small particles of dirt might impair the work in process, a positive filtering arrangement consisting of a separator manufactured especially for the purpose is essential. For operations where a small amount of fine material would blow through the equipment without seriously damaging it, a simple, less expensive arrangement of dust leg placed at the end of the station pipe drop with an inlet screen-type of station valve mounted laterally on the station drop pipe has been found satisfactory.

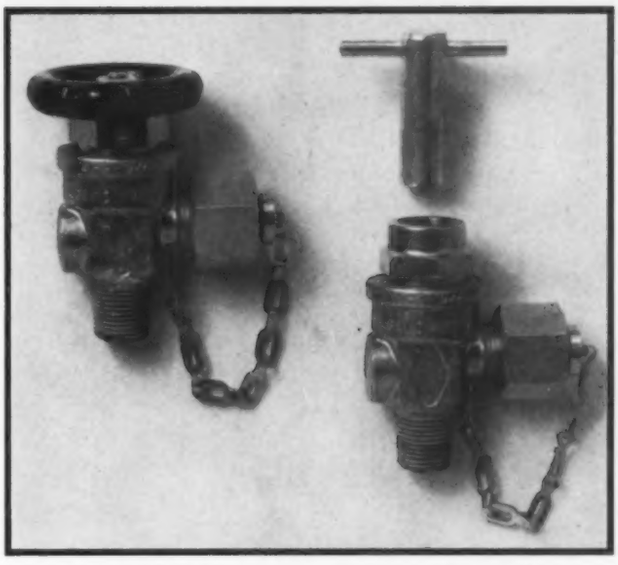


Figure 8 — Oxygen station valves, of either hand wheel or detachable key types, are of packingless, diaphragm type, with heavy pressure forged bronze bodies.

The sizes of pipe employed for oxygen and acetylene distribution piping systems should be accurately calculated values based on a well-considered evaluation of the operating factors involved. These factors are the inlet pressure, the rate of flow, the length of run and the allowable pressure drop. For oxygen-piping systems the inlet pressure is determined by that required for the highest pressure operation to be served. For acetylene systems, however, it is limited to the maximum pressure that can be delivered by the supply unit equipment without exceeding its established safe operating pressure. The flow load allowed for each supply main and service branch section should be computed from consumption rate data obtained by a careful survey of usage operations, making due allowance for maximum load conditions, and for any potential extension of existing usage or anticipated new operations which would augment the flow rate demand. The total pressure drop between the supply unit and the farthest stations should be kept within appropriate limits, and be distributed proportionately among the separate sections comprising the separate runs.

In oxygen-piping systems, an excessive line pressure drop is objectionable because it prevents the maintenance of the same pressure throughout the system, because it causes a large variation in line pressure to occur when the flow load changes due to individual operations starting or stopping, and because it requires a higher delivery pressure at the supply unit than would otherwise be required. To minimize these objectionable effects satisfactorily, the total full-load pressure drop allowed for the longest sequence of consecu tively connected sections should not exceed 5 per cent of the inlet pressure at the supply unit. In the case of acetylene piping, where the pressure available at the supply unit is limited to a value of 15 psi or less, the

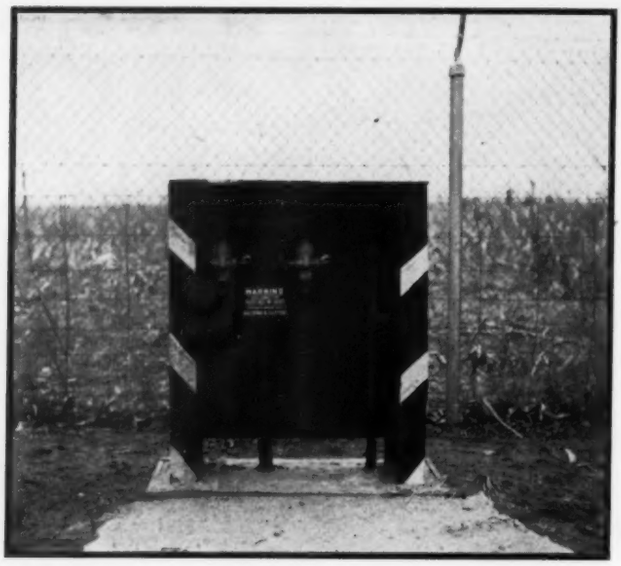


Figure 9 — Station box for underground supply lines in a large scrap yard. Acetylene outlets (left) are equipped with hydraulic back pressure valves. Oxygen outlets (right) have valve for connection of portable pressure regulators.

best practice is to keep the total pressure drop under 1 psi.

In calculating the pipe sizes, the most satisfactory system for apportioning the total pressure drop among the separate sections of the supply runs, is to assign the major part of the total pressure drop to the main or feeder sections. This distribution of the total allowed pressure drop minimizes the variations in pressure caused by the changes in flow load that occur when individual operations start or stop, because the flow loads occurring in main or feeder sections are not subject to the same degree of change as those in service branches, where the consumption of the individual operation is an appreciable portion of the total flow load.

In designing piping to deliver oxygen to equipment, such as hot scarfing machines, which require supply at a very high rate for short intervals, it is often desirable to employ an arrangement that will avoid the use of the exceptionally large pipe that would otherwise be required to keep the pipe line pressure drop within the limits satisfactorily for service to other operations. The arrangement employed in such cases depends on the conditions involved. If the machine locations is not too far away from the supply unit, a separate supply line of the smallest size that will deliver the oxygen at the maximum line pressure required at the machine location will serve satisfactorily. Where there is an existing large-sized main in the vicinity of the machine, the use of oxygen storage receivers at the machine location may be sufficiently effective in reducing the pipe supply demand to permit its being supplied by a service branch from the existing main. When the necessity of supplying the machine is known in advance of the installation of the plant distribution system, it may be appropriate to plan a supply line to the machine, which will also serve to supply service branches in other mills located en route to, or beyond the location of the machine. In this case, economy in pipe size can be effected by designing the main supply section for the smallest size that will deliver the pressure required at the machine, and then providing line pressure-regulating stations for the inter-connected branch lines in which the line pressure variation caused by operation of the machine would be objectionable.

CONSTRUCTION OF DISTRIBUTION PIPING SYSTEMS

As evidenced by the operating records of the large number of installations now in service for a considerable period of years, trouble-free performance and satisfactory service life are effected in distribution piping systems constructed in accordance with the high-quality standards called for in the installation specifications which have been developed especially for oxygen- and acetylene-distribution piping systems. While these specifications are exacting in all items that would affect the performance or serviceability of the completed system, the materials stipulated are readily obtainable items of standard manufacture and the workmanship is that which can be provided by mechanics qualified for construction of welded piping.

The construction specifications for both oxygen and acetylene piping systems stipulate the use of black steel pipe. Steel pipe is well suited for such service. Its strength, soundness, weldability, and other desirable physical qualities are well-known. Contrary to what might be expected, commercially pure oxygen in distribution piping systems does not corrode the internal surfaces of the steel pipe, at least not to say noticeable extent in the case of piping used for oxygen service for a number of years. Extra-heavyweight pipe has been a standard specification for oxygen service until the recent necessity for conservation of steel initiated consideration and approval of the use of standard weight. Standard-weight pipe has ample strength for the pressures involved in oxygen distribution piping systems but, being of lighter wall thickness, requires more care in the matter of supports, and in protection against abrasion and external corrosion.

Welded construction is specified for the indisputable benefits of permanent joint strength and leak tightness. Welded joints are employed wherever possible, the only exceptions being joints at equipment such as shutoff valves, separators, pressure-reducing regulators, etc., which require screw connection. The tightness of the screwed joints at such equipment is made as thorough and permanent as possible by the use of solder-sweated assembly, or a litharge-and-glycerine thread seal for oxygen, or white lead thread seal for acetylene.

The pipe and all equipment used in oxygen piping systems must be completely free of oil, grease, and similar organic materials, to avoid the possibility of their spontaneous combustion and damage to the piping or associated service equipment. This precaution is provided for in the construction specifications for oxygen-distribution piping systems, which stipulate washing of all pipe, valves, fittings and equipment; and a special construction procedure to avoid contamination after washing.

Oxygen and acetylene piping should be adequately supported by methods adapted to meet conditions ex-

isting in its vicinity. Support by pipe rings and hangers, or by brackets and clamps is suitable for pipe installed inside of buildings. Cables, trusses, or towers should be provided for the support of piping run overhead between adjacent buildings. Where excessive vibration of the structure from which the pipe is supported is a factor, care should be exercised to avoid the use of sharp-edged or narrow supports that would cause objectionable wear of the pipe wall. In arranging supports and fastening the pipe to them, proper allowance should be made to permit the movement of the pipe that will result from temperature changes. If these provisions are made, the installation of expansion joints or expansion loops will not be required.

Provisions for draining of condensate are not ordinarily required on oxygen-distribution piping, because the types of oxygen-supply units in common use deliver a gas that is either completely dry, or sufficiently dry to preclude precipitation in the piping system. All distribution piping systems for generated acetylene, however, require adequate provisions for draining the water condensate which is precipitated from the gas as it cools in its passage through the piping. While most of the condensate generally occurs in the first 500 feet of piping out of the generator building, good design calls for grading of the pipe and installation of drip pots along the runs to a distance beyond which there is little or no possibility of further cooling of the gas. In the case of overhead piping located in buildings which are a considerable distance from the generator building, drainage of the service branches through the station drop piping is generally satisfactory, so that drip pots and grading need only be applied for extremely long runs and at low points resulting from unavoidable changes in pipe elevation.

All piping for oxygen- or acetylene-distribution systems should be subjected to a thorough leak test before being placed in service. The most practical procedure for testing large piping systems is to test the piping in sections as completed, by a soapsuds test applied to the joints, and later test the complete system by means of a 24-hour, standing-pressure test. With this procedure, any leakage at joints will be detected and located by the initial soapsuds test; and the occurrence of any leakage through pipe seams, or leakage overlooked in the joint tests will be indicated by the final standing-pressure test.

Only water-pumped air or other approved, oil-free, noncombustible gas should be employed for testing or blowing out oxygen piping. Shop compressed air is suitable for testing acetylene piping systems. Inert gases, such as nitrogen, are also employed for testing acetylene piping systems, but the use of an inert gas instead of the more available compressed air is not essential, since the air left in the piping after testing can be safely purged from the system with acetylene by a relatively simple procedure when the system is placed in service.

The corrosion protection required for oxygen and acetylene piping is limited to that needed to preserve the external surfaces, as neither gas is corrosive to the steel pipe, or to the cast iron and non-ferrous materials used in the accessory line and outlet station equipment. An undercoat of red lead and two cover coats of a good-quality pipe enamel are generally adequate for piping located above ground. For ordinary soil conditions, satisfactory protection of pipe placed underground can be obtained by a prime coat of coal tar paint, followed by a heavy coat of roofing pitch applied hot and wrapped with a good grade of tarred felt. Layers of slacked lime, or carbide residue, placed around previously coated pipe, has been found very effective for piping located in cinder fill or distinctly acid soil.

OPERATION AND MAINTENANCE OF DISTRIBUTION PIPING SYSTEMS

Only a limited amount of operating supervision is required to develop safe and trouble-free performance on oxygen- and acetylene-distribution systems. This supervision should restrict all use of the piping systems to accredited oxy-acetylene equipment operators, and all repair or alteration work to properly instructed maintenance personnel. This restriction of use of the gases can be effectively furthered by employing a style of outlet valve that requires a key-type detachable wrench handle for opening it, and by posting an appropriately worded warning sign at each outlet station. Operating supervision should also provide for regular inspection of the piping systems to check the condition of equipment and promote diligence on the part of oxy-acetylene equipment operators to close and cap station outlet valves when the outlets are not in service.

The maintenance of oxygen- and acetylene-distribution piping systems, while normally a matter of small expense, should be complete and thorough. Periodic leakage tests, especially of threaded connections and packed-type shutoff valves, should be an established feature of the maintenance program. Operators' hose and equipment should also be subject to periodic test to keep them leak-free and in good working order. Locations where abrasion, corrosion, or other sources of damage to the pipe are exceptionally severe should be inspected regularly to permit necessary repair before the piping is seriously damaged.

INSTALLATIONS IN SERVICE IN STEEL PLANTS

Statistics on steel plant installations of oxygen and acetylene supply units and distribution piping systems are difficult to furnish, because the large amount of steel processing and fabrication in many plants can be interpreted to qualify them as steel plants. Considering only the larger installations in plants whose primary product is semi-finished steel, and of these, only those plants which we serve as customers, over 50 steel plants are now equipped with large-size oxygen-distribution piping systems. Complementing these in the same group of steel plants are some 30-odd large size acetylene generator and distribution piping systems.

Complete data on the size of these installations are also difficult to furnish because, while we have accurate data on the amounts of pipe in the original systems, most of the systems have been extended considerably by additions made later. On the original installation basis, the sizes of the oxygen-distribution piping systems range from 10,000 to 50,000 lineal feet per system, and the acetylene systems from 5000 to 30,000 lineal feet.

Since installation, many of these systems have been increased 20 to 50 per cent in extent, by later additions.

While these statistics are too general to permit computing the total footage of oxygen and acetylene distribution piping systems in steel plants, such a value is only of academic interest at best. Much more important is the fact that these data serve to show that there is a very general acceptance and use of central supply units and distribution piping systems for oxygen and acetylene, and that such systems can profitably be as large in extent as is necessary to serve the locations of permanent consumption. Further evidence of the appreciation of the benefits of such service systems is convincingly furnished by the extensive piping additions which nearly every plant has made in order to extend the piped supply to other usage areas.

DISCUSSION

PRESENTED BY

F. E. KLING, Assistant Chief Engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

H. I. SAMSON, Welding Department, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

HERMAN ULLMER, Manager, Process Service, The Linde Air Products Company, New York, New York

F. E. Kling: Oxygen has been of great benefit to the industry as a whole and the iron and steel industry in particular. I happened to live through the entire development, which started sometime during the first decade of this century. It was very difficult at that time to get anything welded. I remember we came to the conclusion that rollers for mill tables should be made of welded construction, taking a piece of pipe, a rolled steel round for the shaft and two pieces of tin bar, welding them together. We could not get it done in Youngstown, but finally located somebody in Pittsburgh who did it. That was back in 1910.

After several years of operation, that design of roller proved to be reliable, cost less and was considerably lighter than cast iron rollers. On the strength of these favorable results it was decided that in connection with the McDonald mills, which were then being contemplated, all the mill table rollers should be of that construction. There are thousands of them in operation there, and many of the original rollers are still running and have been for twenty-five years.

That is an example of what effect oxygen has had on mill design, but not only has the design of the steel plant structures and equipment been benefited, but also the operation, for instance, the opening of tap holes, of open hearth and blast furnaces, cutting of scrap, and so forth.

H. I. Samson: I would like to ask Mr. Ullmer if, at outlet stations on medium pressure acetylene systems, there is any advantage in the hydraulic flashback arresting valve over the approved service regulator and check valve, from the safety standpoint.

Herman Ullmer: The question of whether the service regulator or the hydraulic back pressure valve should be used is a matter that has been debated for a good many years, and there is still considerable difference of opinion. I believe the type of equipment used should be decided by considering the conditions that will apply in operating the torch equipment. For example, for work with torch equipment that requires a fine adjustment and close control of the acetylene pressure, I would use the regulator; but for some of the more rugged applications, such as scrap cutting and deseaming, where a fine control of the acetylene pressure is not so important, but where protection from flashback is highly important, I would use the hydraulic back pressure valve.

If there was any doubt in my mind as to whether I could get the desired results with either one or the other, I would use both. Each has its own advantage and they function very satisfactorily for the purpose for which they are designed.

H. I. Samson: In cases where it is difficult to prevent your flashback, you would say that the service regulator and a mechanical check valve in the acetylene line would be perfectly satisfactory?

Herman Ullmer: The only use of a check valve I would recommend is that in the hydraulic back pressure valve, where the check valve is under water. In this case, the check valve closes under the seal of water and the back pressure of the flashback is released through the pressure relief valve. That is the only use of a check valve I would recommend. I wouldn't consider use of an ordinary check valve by itself.

H. I. Samson: And the approved service regulator acts as a safety from flashback into the acetylene line?

Herman Ullmer: It is so recommended and recognized by the regulatory bodies but, as I said, if the conditions were severe, I would resort to the hydraulic back pressure valve. In this device you have the combination of water seal, check valve and pressure relief.

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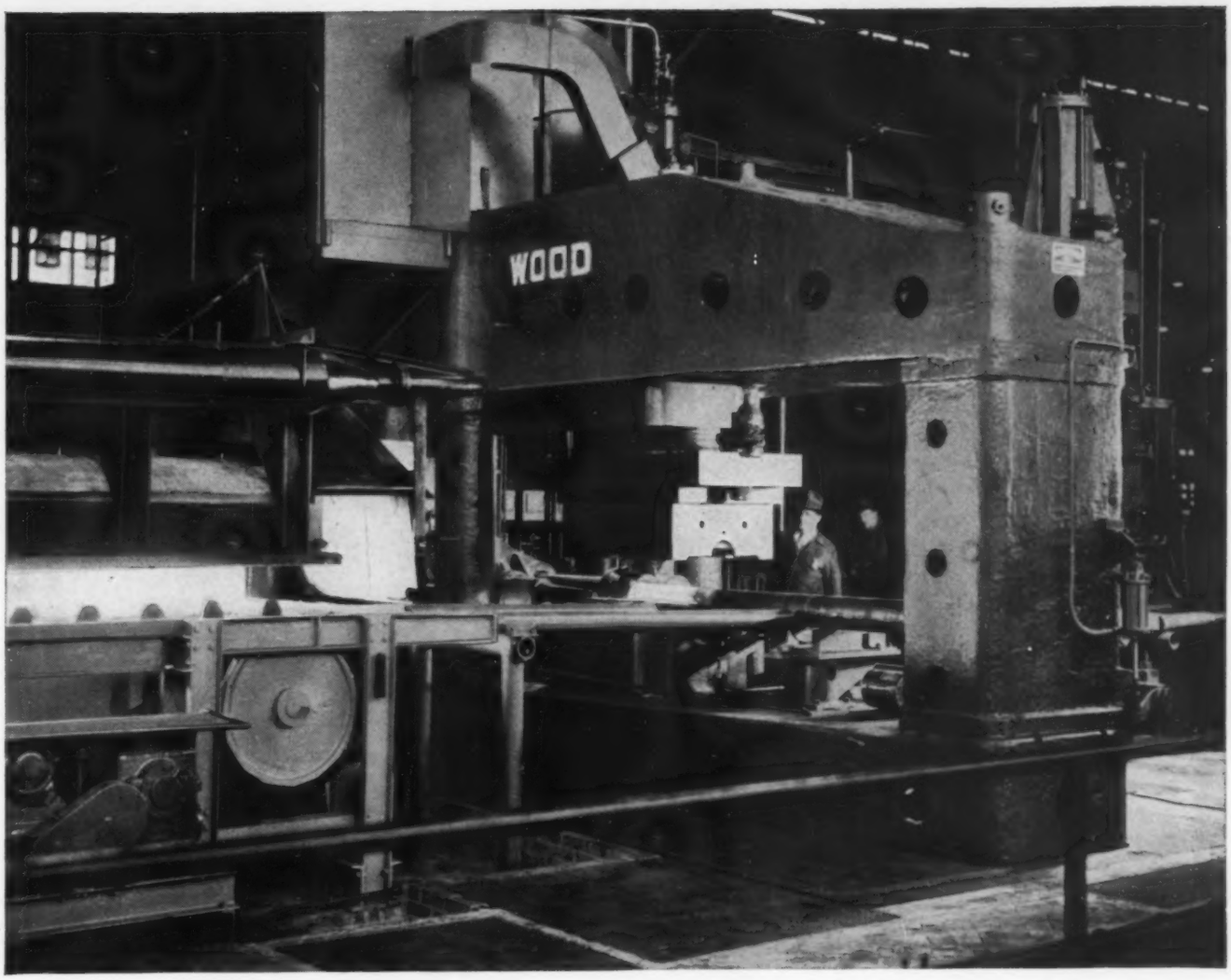

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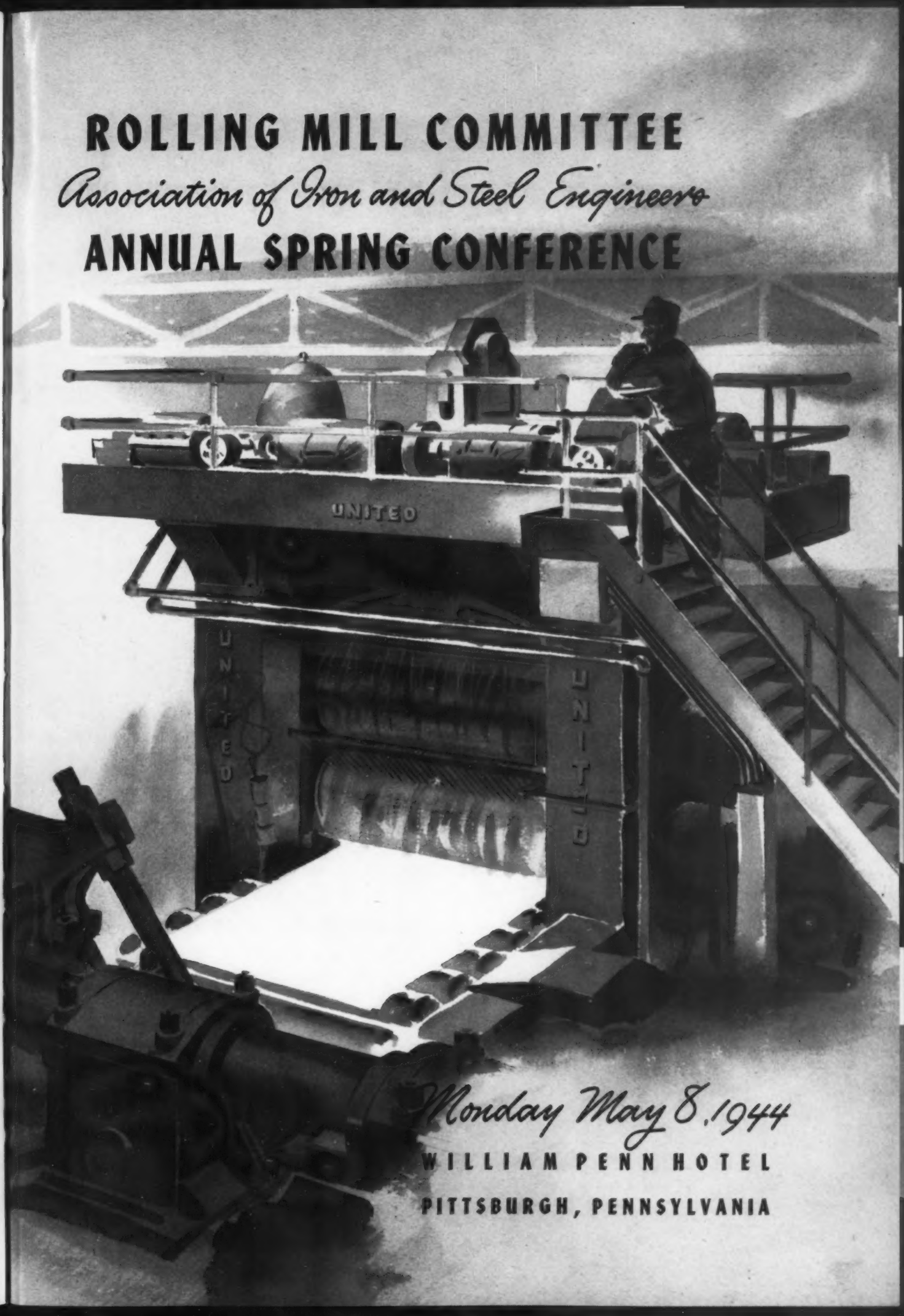
Association of Iron and Steel Engineers

ANNUAL SPRING CONFERENCE



Monday May 8, 1944

WILLIAM PENN HOTEL

PITTSBURGH, PENNSYLVANIA

LOUIS MOSES

J. L. MILLER

T. B. McELRAY

J. B. MITCHELL

Annual Spring Conference

ROLLING MILL COMMITTEE

Programme

9:00 A.M. — REGISTRATION — Silver Room

9:30 A.M. — *Technical Meeting* — Urban Room

Chairman:
LOUIS MOSES, Superintendent
Rail Mill and Roll Department
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
J. L. MILLER
Assistant Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

"Operating the Continuous Furnace by Automatic Temperature Control," by B. M. PUTICH, Combustion Engineer, A. M. Byers Company, Ambridge, Pennsylvania.

"Heating and Rolling in Bar Mills," by J. L. McHUGH, General Foreman No. 18 Mill, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

William Penn Hotel, Pittsburgh, Penna.

B. M. PUTICH

J. L. McHUGH

W. B. SNYDER

Chairman:

T. B. McELRAY
Electrical Superintendent
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice-Chairman:

J. B. MITCHELL
Superintendent of Rolling Mills
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

1:30 P.M. — *Technical Meeting* — Urban Room

"Main Roll Drives for Merchant, Bar and Rod Mills," by W. B. SNYDER, Steel Mill Engineer, General Electric Company, Schenectady, New York.

"The 26 In. and 22 In. Mills at Atlas Steels, Ltd.," by C. P. HAMMOND, Superintendent of Mills, and A. M. CAMERON, Roll Designer, Atlas Steels, Ltd., Welland, Ontario, Canada.

"Steel Roll Manufacture and Application," by DR. F. H. ALLISON, Chief Metallurgist, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

C. P. HAMMOND

A. M. CAMERON

F. H. ALLISON

6:30 P.M. — DINNER

(Speaker to be announced)

Monday, May 8, 1944

PURDY PIX

An Invitation

TO STEEL MEN

One year ago the Rolling Mill Committee of the Association of Iron and Steel Engineers launched its activities at the annual spring meeting with a fine program dealing with blooming and slabbing mills. The reception accorded this new committee emphasizes the interest in this field of the industry. Growth has been rapid.

Through the efforts of the Rolling Mill Committee, our monthly magazine, the *Iron and Steel Engineer*, has been able to present a remarkable collection of information on various types of rolling mills — information never published before and available from no other source. With the continued growth and activity of the committee, much more data of like nature will be forthcoming. With steel plate continuing to receive top attention, the survey of modern plate mills included in the April issue of *Iron and Steel Engineer* is particularly timely. The program for the second meeting sponsored by the Rolling Mill Committee carries much of interest to those operating secondary mills.

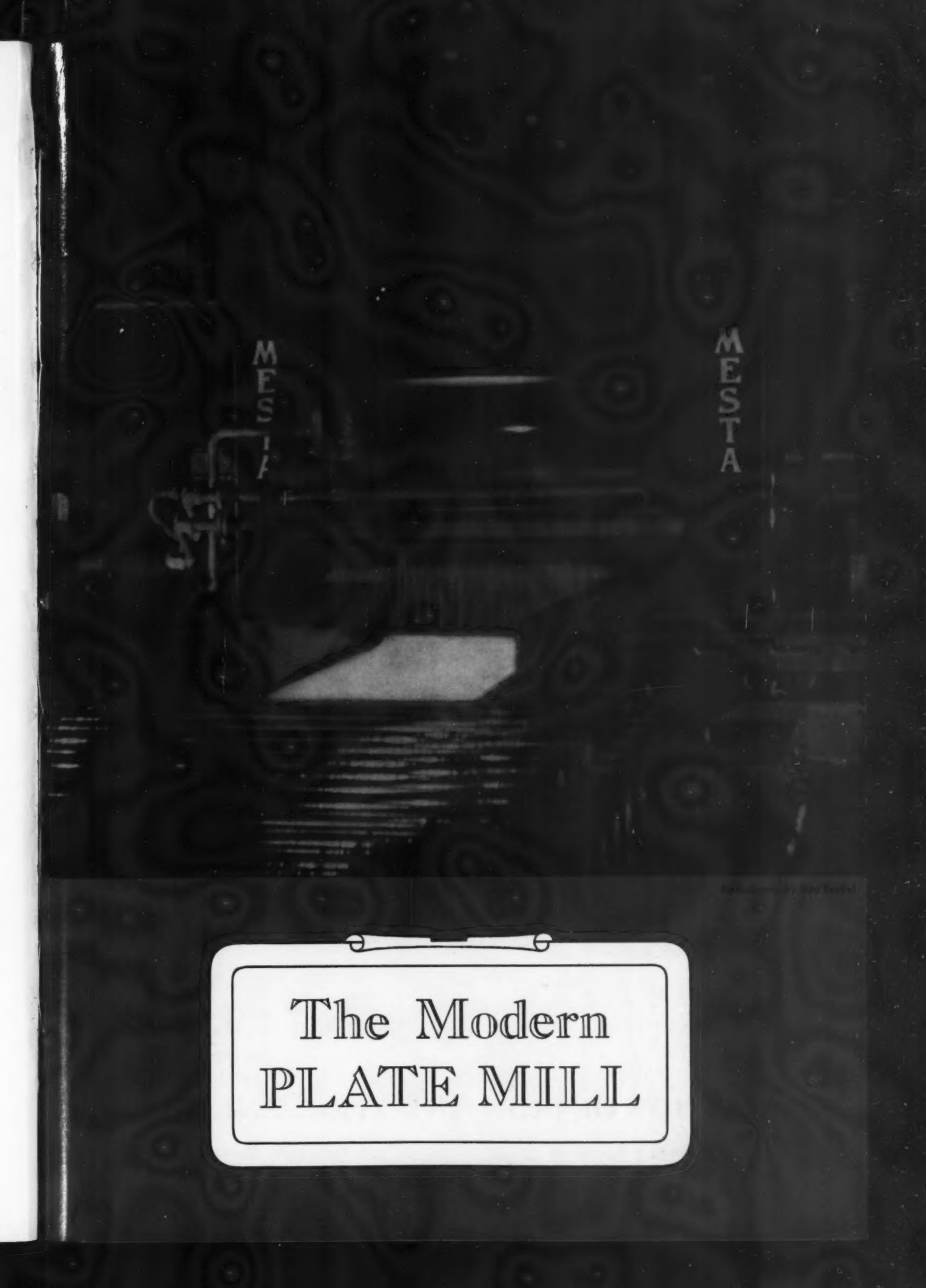
In the sincere belief that the steel industry will benefit greatly through the activities of the Rolling Mill Committee, I wish to extend to each one of you an earnest invitation to participate in this meeting and to identify yourself with the work of this committee.

Chas. L. McGranahan

PRESIDENT

ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 Empire Building **Pittsburgh, Penna.**



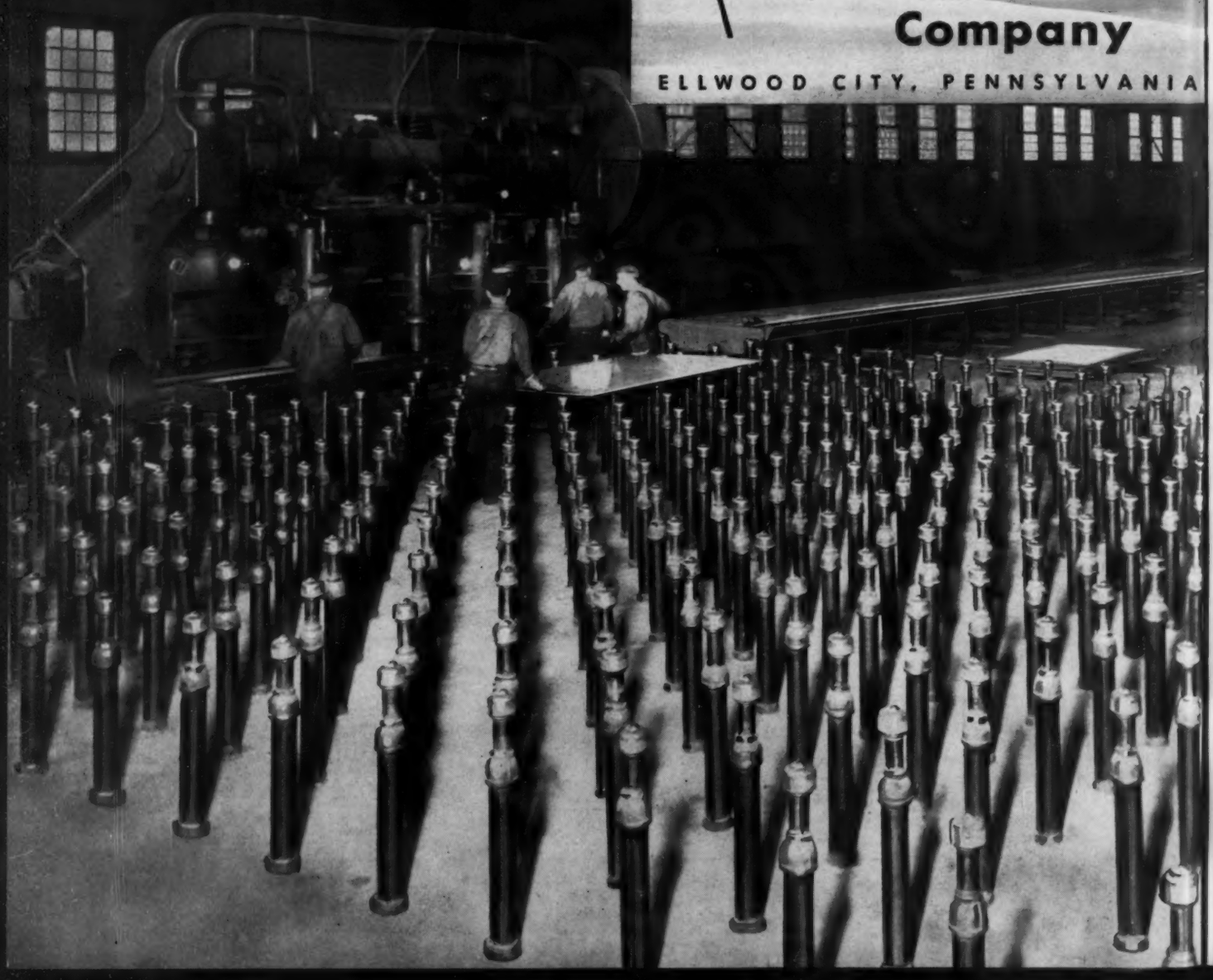
The Modern PLATE MILL

Getting New Ships to Sea

Our great Allied shipyards are doing a magnificent job for Victory, getting more ships down the ways than were hoped for, even by the most optimistic. Mathews Ball Transfers are on the job in these great yards, handling plates from the shears, punches, and presses. These transfers are without equal as a method for positioning ship plates, and there are many other applications for which they are ideal. They are made in sizes ranging from 50 lb. capacity to 1,000 lbs., and can be furnished for pedestal, bed plate, or special mounting. Write for descriptive literature and data sheets describing these units.

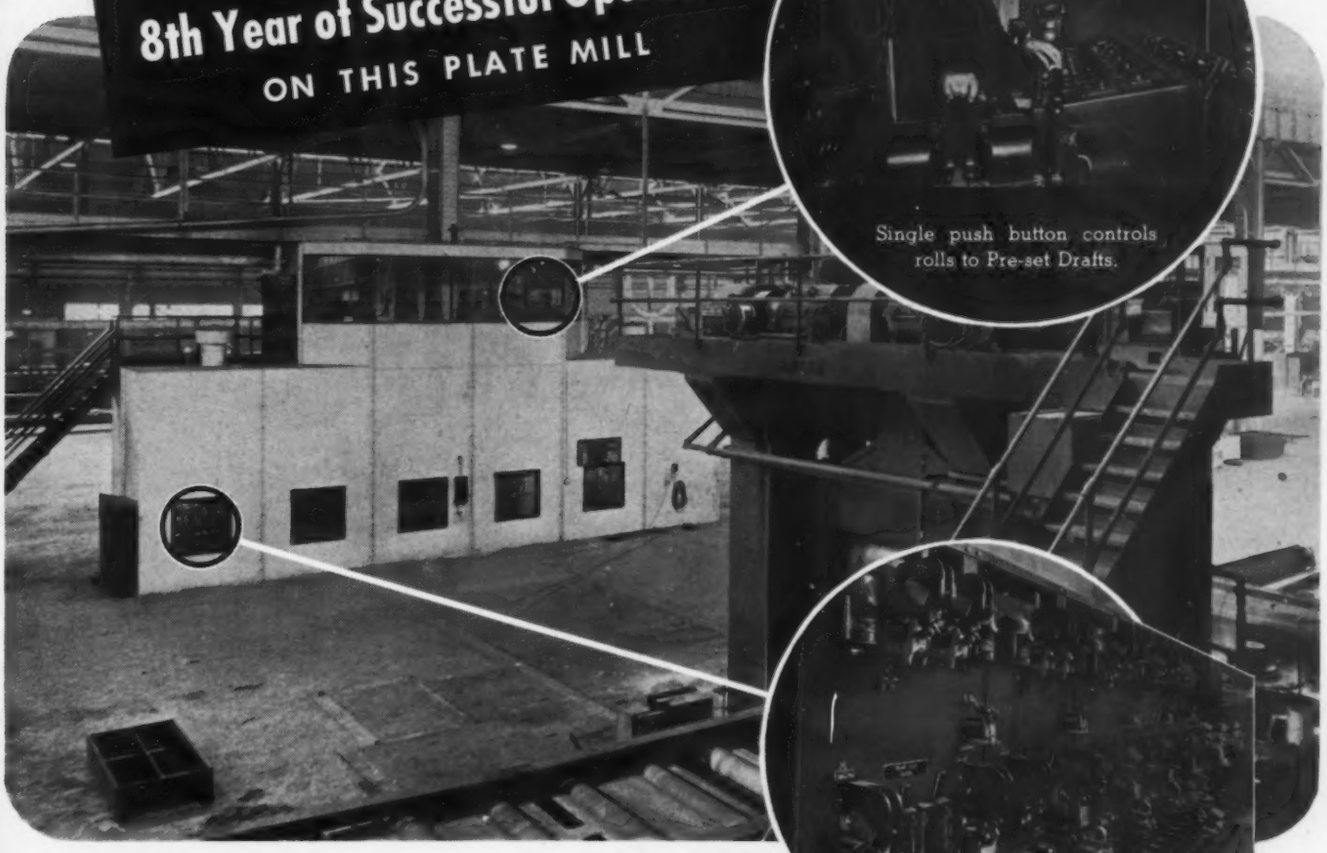
Mathews Conveyer Company

ELLWOOD CITY, PENNSYLVANIA



EC&M LINE-ARC
CONTACTOR CONTROLLERS IN THE 8th Year of Successful Operation ON THIS PLATE MILL

Single push button controls rolls to Pre-set Drafts.



Partial view of TIME-CURRENT Controllers serving this mill.

WITH this mill operating on an accelerated schedule—possibly two to three times that of normal years, due to war-time demands—these EC&M LINE-ARC Contactor Controllers have established new records in low maintenance costs and time-outs.

Selected in 1936 for the operation of hard-worked drives on this 100" Plate mill such as screwdowns, side guides, etc., this EC&M Control installation is operated automatically through Pre-set Drafts and has resulted in high production of accurately finished products.

Our nearby office will be glad to explain the merits of LINE-ARC Contactor Controllers and Automatic Pre-set Control.

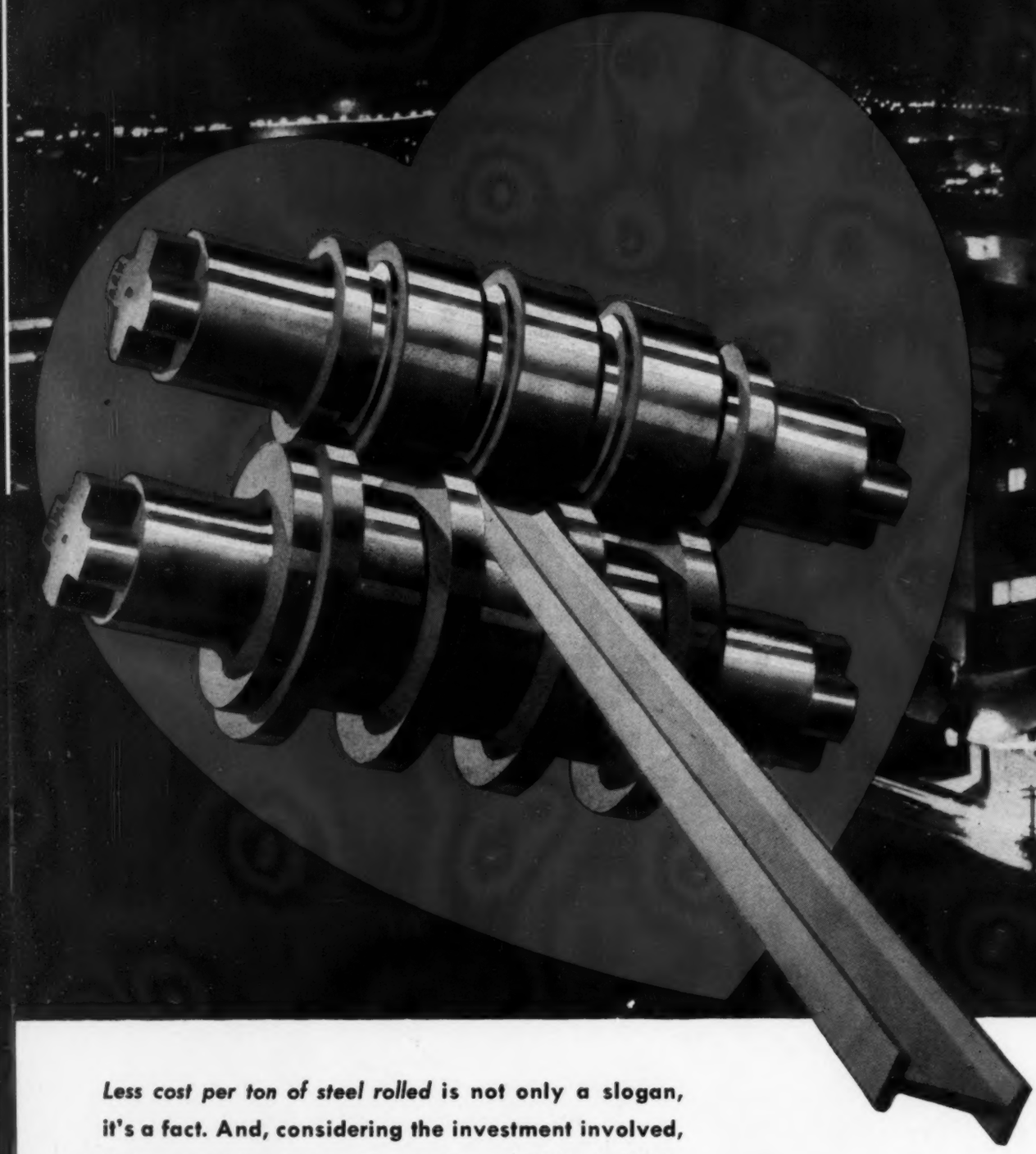
OUTSTANDING FEATURES OF LINE-ARC

1. Cool operation insures long contact-life.
2. Control of the arc prevents destructive burning of arc shields.
3. High-speed operation permits quick response—accurate moves.
4. Continuous capacity operating coils.
5. Long bearing life with nitralloy pins and self-lubricating bearings throughout.

THE ELECTRIC CONTROLLER & MFG. COMPANY

2698 E. 79th STREET — CLEVELAND 4, OHIO

THE *HEART* OF THE ROLLING MILL



Less cost per ton of steel rolled is not only a slogan, it's a fact. And, considering the investment involved, it is good business to specify Pittsburgh Rolls and get the utmost from the "heart" of your mills.

BUY U. S. WAR BONDS AND STAMPS

PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of BLAW-KNOX CO. — "Steel's Partner" • PITTSBURGH, PA.

New Runout Table Development Features DODGE-TIMKEN PILLOW BLOCKS

As part of its extensive contribution to the war effort, the Dodge Manufacturing Corporation, Mishawaka, Indiana has developed a new method of producing rollers for mill runout tables.

The rollers are fabricated from heavy-wall seamless steel tubing, into the ends of which are shrunk and welded, machined cast steel gudgeons. Each roller measures 12¾" O. D. x 84" face and is carried in a pair of standard 3 15/16" Dodge-Timken Double Interlock Pillow Blocks, which in turn are bolted to an especially designed table girder. A shop assembly view of a small section of runout table constructed in this way is shown above.

The Dodge Manufacturing Corporation has also brought out another table roller design in which special Dodge-Timken Prest-On Pillow Blocks are used. The bearings used in these pillow blocks are Timken NA Bearings, provision for floating to take care of expansion being made at one end of the roller. These rollers are equipped with individual electric motor drives.

Hundreds of Dodge-Timken Table Rollers have been installed and are operating with great satisfaction. Further information can be obtained direct from the Dodge Manufacturing Corporation, Mishawaka, Indiana. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TAPERED ROLLER BEARINGS

UNITED

Builders of

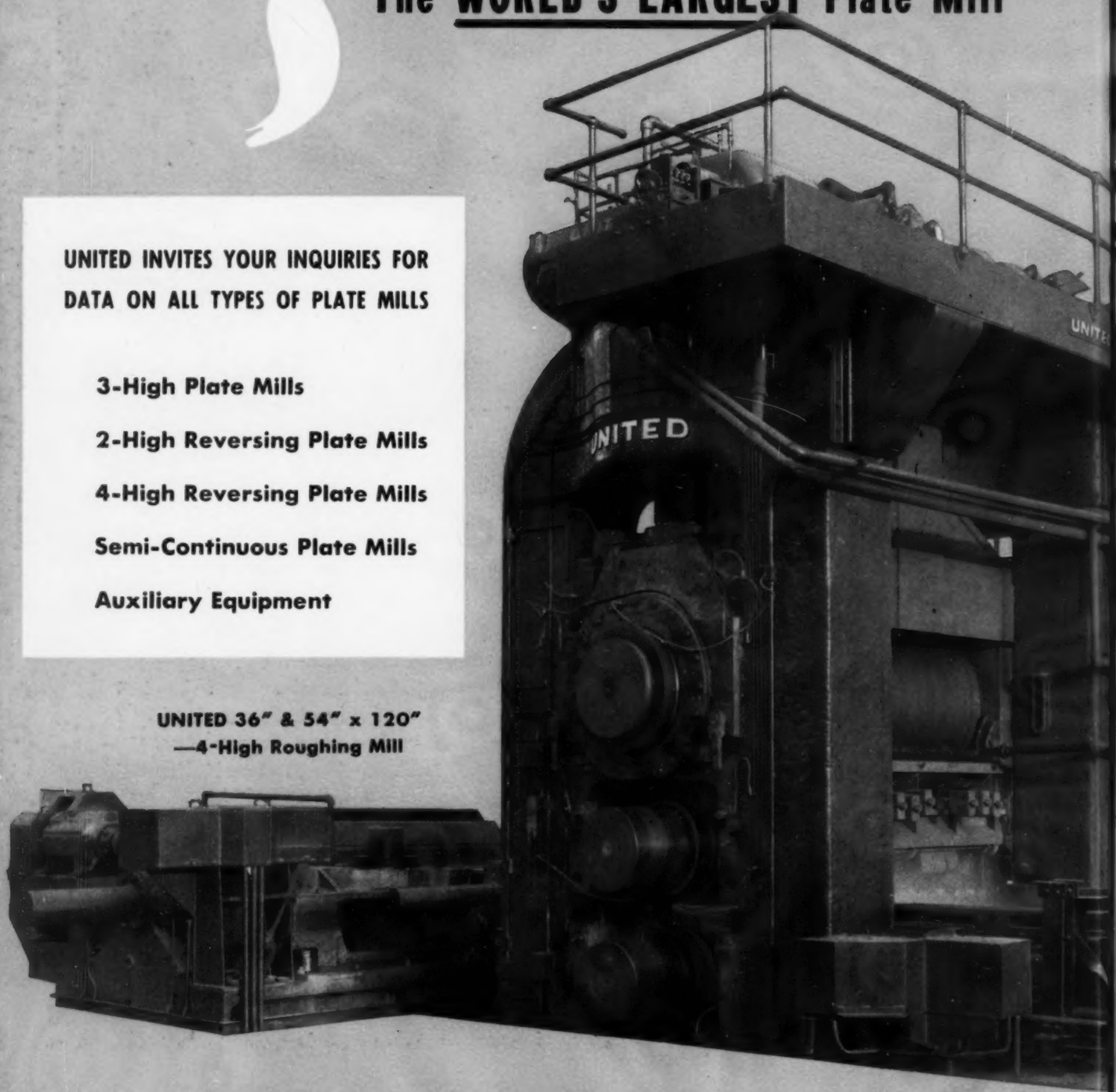
The FIRST 4-High Reversing Plate Mill

The FIRST Semi-Continuous Plate Mill

The WORLD'S LARGEST Plate Mill

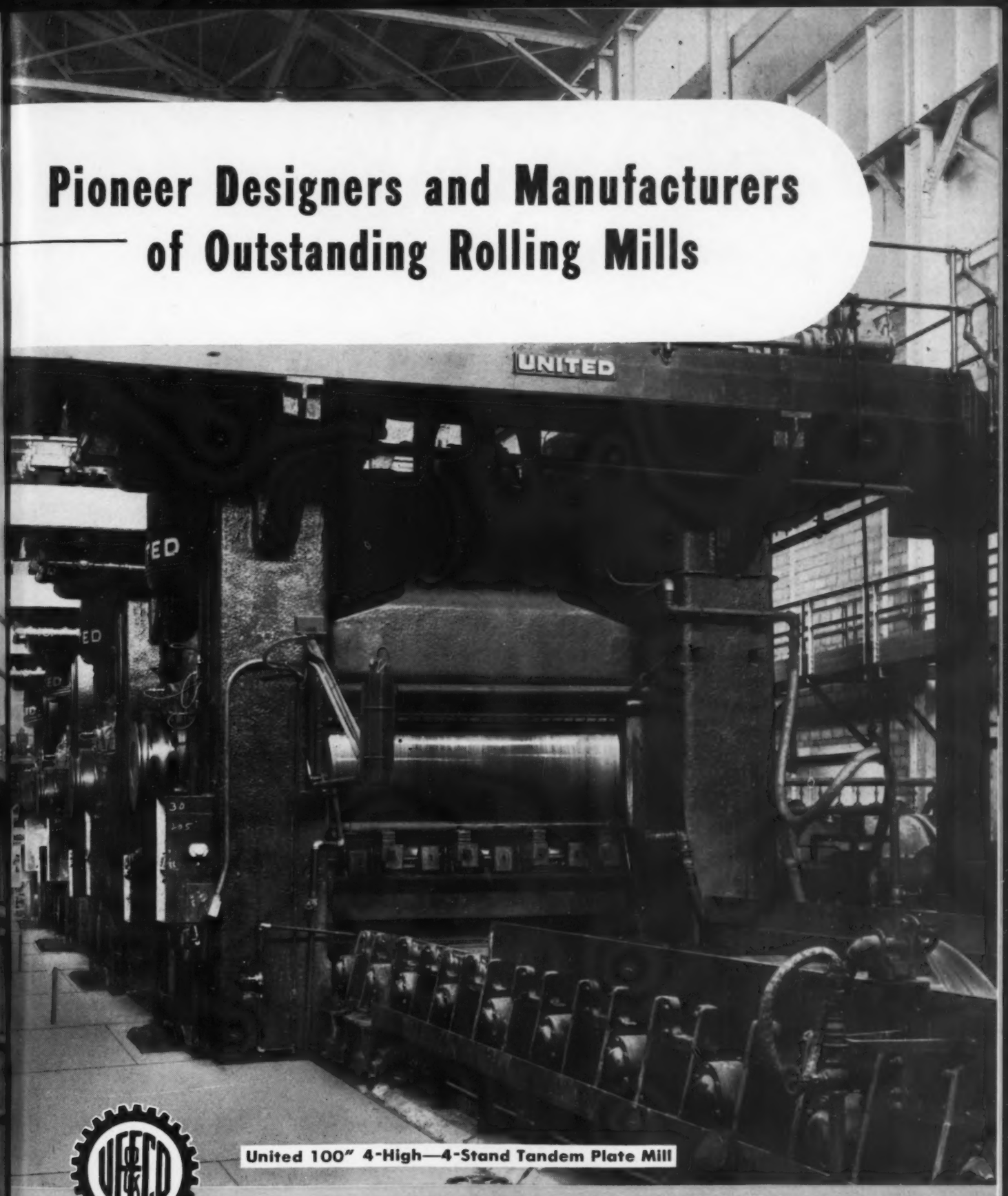
UNITED INVITES YOUR INQUIRIES FOR DATA ON ALL TYPES OF PLATE MILLS

- 3-High Plate Mills
- 2-High Reversing Plate Mills
- 4-High Reversing Plate Mills
- Semi-Continuous Plate Mills
- Auxiliary Equipment



UNITED 36" & 54" x 120"
—4-High Roughing Mill

Pioneer Designers and Manufacturers of Outstanding Rolling Mills



United 100" 4-High—4-Stand Tandem Plate Mill

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

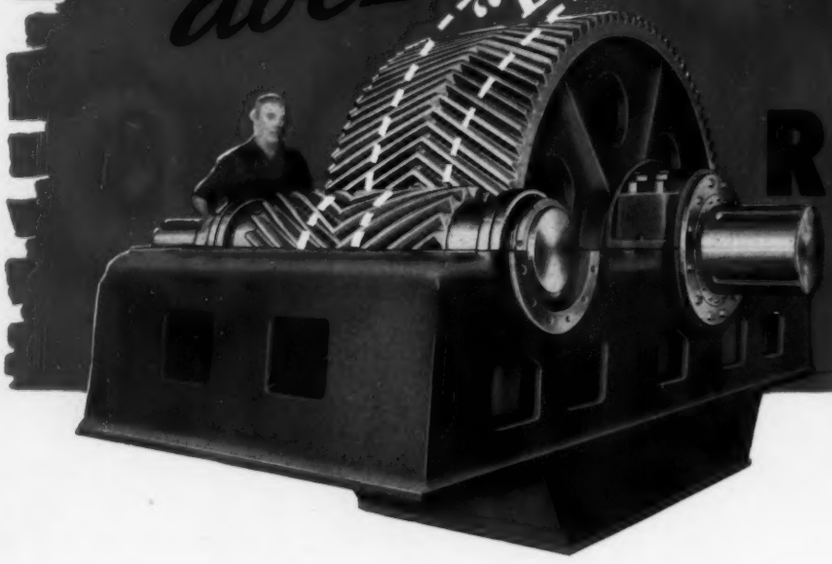
Plants at PITTSBURGH, VANDERGRIFT, NEW CASTLE, YOUNGSTOWN, CANTON

DAVY AND UNITED ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND

DOMINION ENGINEERING WORKS, LTD., MONTREAL, P. Q. CANADA

** The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment*

What does "BACKBONE" mean in a ROLLING MILL DRIVE?



FARREL
The Gear with a Backbone

The *backbone* in Farrel-Sykes herringbone gears is where the two helices meet in sharp apices — shown between the dotted lines in the photograph. Some herringbone gears have a center groove in this space. The groove serves no useful purpose. It is there because the machines used in making the gears are unable to cut continuous teeth.

Because the teeth are continuous, the entire face width is put to work, providing high load carrying capacity and extra strength to withstand the stresses, shocks and wear incident to high speeds and heavy loads.

In addition Farrel-Sykes continuous tooth herringbone gears have other important advantages. Precision generation by the Sykes process makes them exceptionally quiet and smooth-running. Their combined characteristics of overlap or interlacing of the teeth, gradual engagement and inclined line of pressure, reduce wear and maintain the involute profile and correct tooth action throughout the life of the gears.

Specially designed for each individual job, Farrel rolling mill drives meet the requirements of modern rolling mill practice and can be depended upon for unfailing service under all conditions of operation. Our engineers will be glad to discuss drive problems with you at any time. No obligation, of course.

●

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN. BUFFALO, N. Y.
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles.

FARREL ROLLING MILL MACHINERY

- Rolls
- Rolling Mills
- Rod Mill Tables and Manipulating Equipment
- Universal Mill Spindles
- Rod Coilers
- Gears
- Mill Pinions
- Pinion Stands
- Gear Drives of any Capacity
- Flexible Couplings
- Roll Grinding Machines
- Roll Calipers
- Lead Presses for Pipe or Rod

Farrel-Birmingham

SALEM

CIRCULAR SOAKING PITS

WILL GIVE YOU SUBSTANTIAL SAVINGS ON YOUR *CONDITIONING* COSTS

More Efficient Heating Control results in **BETTER QUALITY** *Steel*

Write Today for Complete Details on the Pit That Saves You More Money Per Ton of Steel Heated.

Direct firing through premixing or nozzle mixing burners spaced around the pit at a tangent to the circular furnace wall provides a 25% faster heating cycle and more efficient heating. With this method, you obtain a desirable mixing action of the gases within the pit. All ingots heat uniformly, resulting in better surface, faster rolling, 1% higher yield, minimum of cinder, with no flame impingement on ingots or furnace walls. Also an empty Salem pit can be quickly cooled to proper temperature for charging.

➡ TREMENDOUS SAVING IN PIT REPAIRS

The correct combustion cycle is maintained and heat is distributed uniformly to the charged ingots . . . without the use of checkers. One superintendent informs us that he has had only minor wall and burner port repairs in the operation of his 20' Salem Pit the past three years.

➡ LABOR SAVING OPERATION

A Salem Pit eliminates all guesswork in preparing ingots for rolling. You merely set the control for desired temperature and the complete heating and soaking cycle is carried out for you. Easy as 1-2-3.

➡ SAVES IN MANY WAYS

The dome shaped cover is the best designed cover ever made for a soaking pit. In one installation, the cover has been in place six years without maintenance and is still going strong.

Because all ingots heat uniformly, they do not have to be moved around to better heating zones. Forgotten corners are eliminated in Salem Ingot Heating Furnaces.

SALEM ENGINEERING COMPANY

SALEM ENGINEERING CO. · SALEM, OHIO

Know your GUIDE

for Unrationed Stakes

STRIP MILL GUIDE
TRANTINYL CAST FOR
SUPER - TONNAGE STAKES

Youngstown Alloy Casting Corporation

YOUNGSTOWN, OHIO

FOR THESE RESULTS USE GATKE moulded fabric SLIPPER BEARINGS

10 times longer service than bronze slippers

Eliminate scoring and wear to companion parts

Stop destructive vibration and pounding noises

Avoid grease slinging

Save costly machining

Replace critical metals

Only GATKE *makes Self-Alyn* Slippers—the GATKE Invention that eliminates breakage, improves lubrication, and prolongs wear life. Made to fit all types and sizes of Universal Couplings and shipped ready to install without machining.

The incomparable results of GATKE Slippers on *all types and sizes* of Universal Couplings leave no doubt that if you are not using GATKE Slippers, *you are missing plenty.*

Please remember that GATKE Slippers are unique—the product of nearly 10 years pioneer development and specialized experience. Many features are protected by GATKE Patents—the tough fabrics are exclusive GATKE developments, manufactured only in GATKE Textile Plants.

Just write for complete information or send specifications of coupling for recommendation.

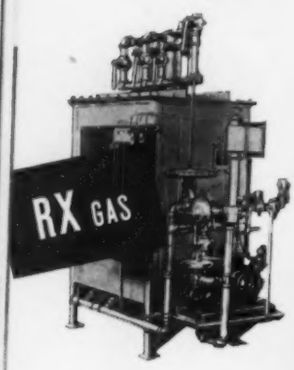
GATKE CORPORATION • 228 N. LaSalle St., CHICAGO

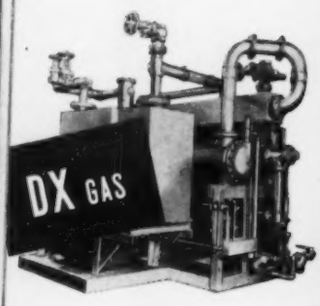
Other **GATKE PRODUCTS**

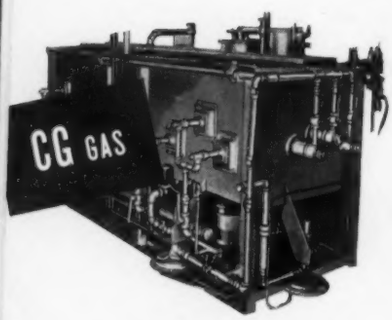
Brake Lining
Clutch Facings
Friction Blocks
Silent Gears
Pump Valves
Piston Rings
Sheet Packings

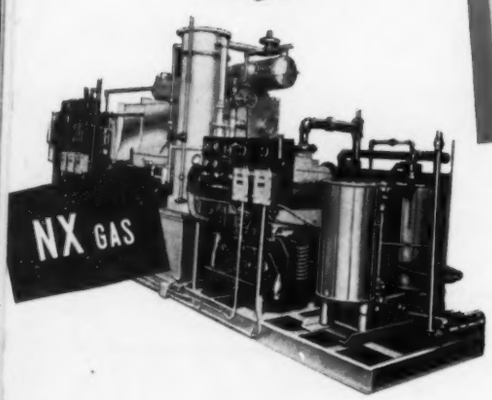
Gatke MOULDED FABRIC Bearings

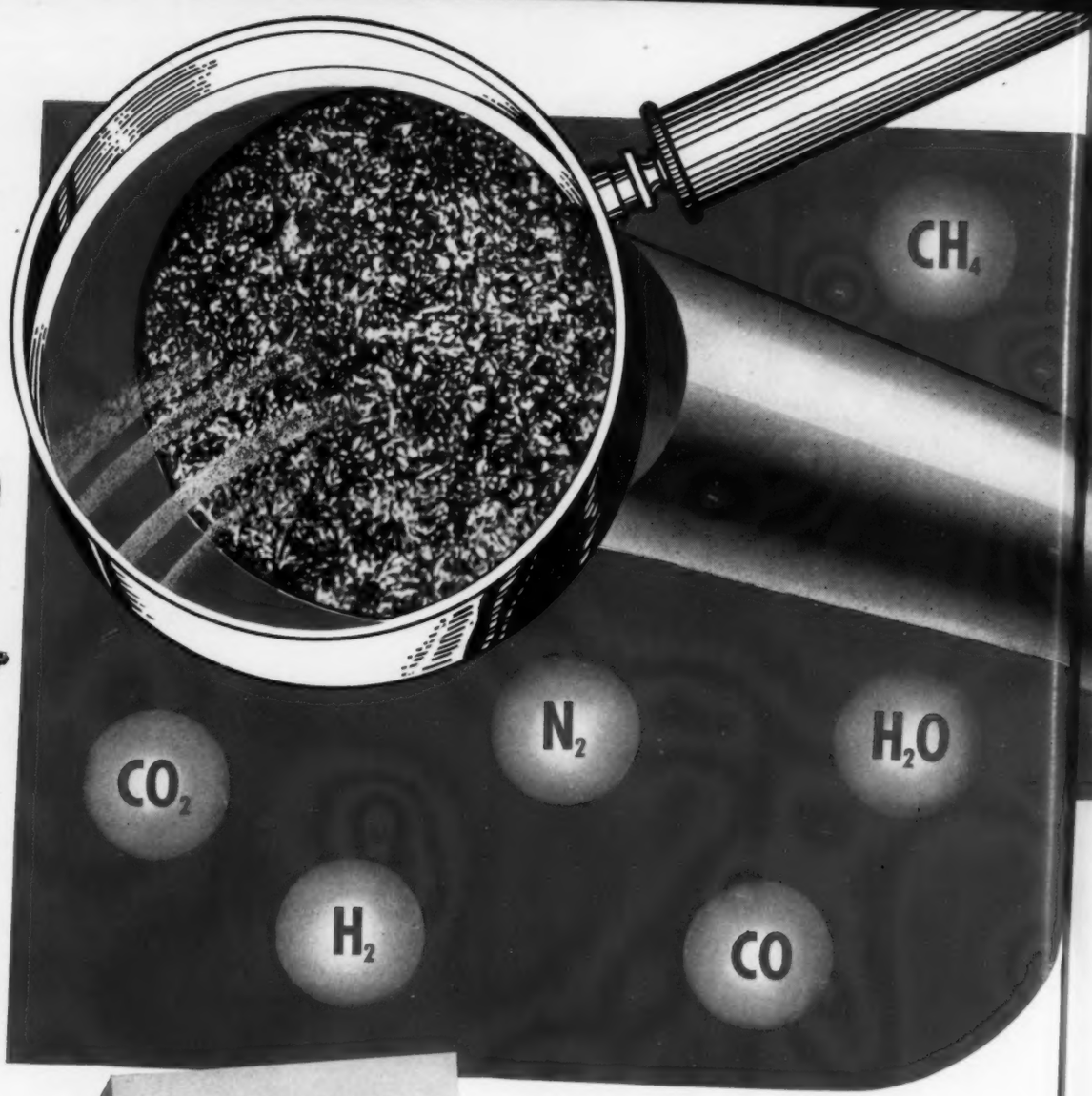
For Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes, Acid Resisting Service, and Other Tough Jobs.









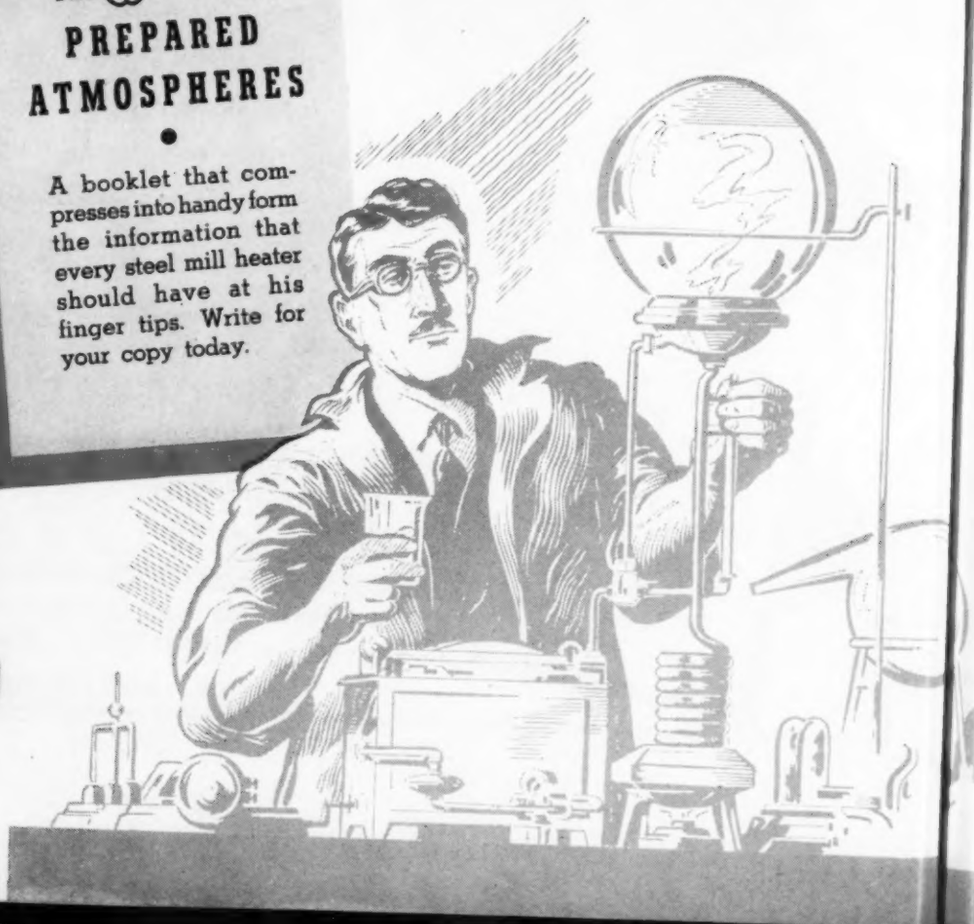


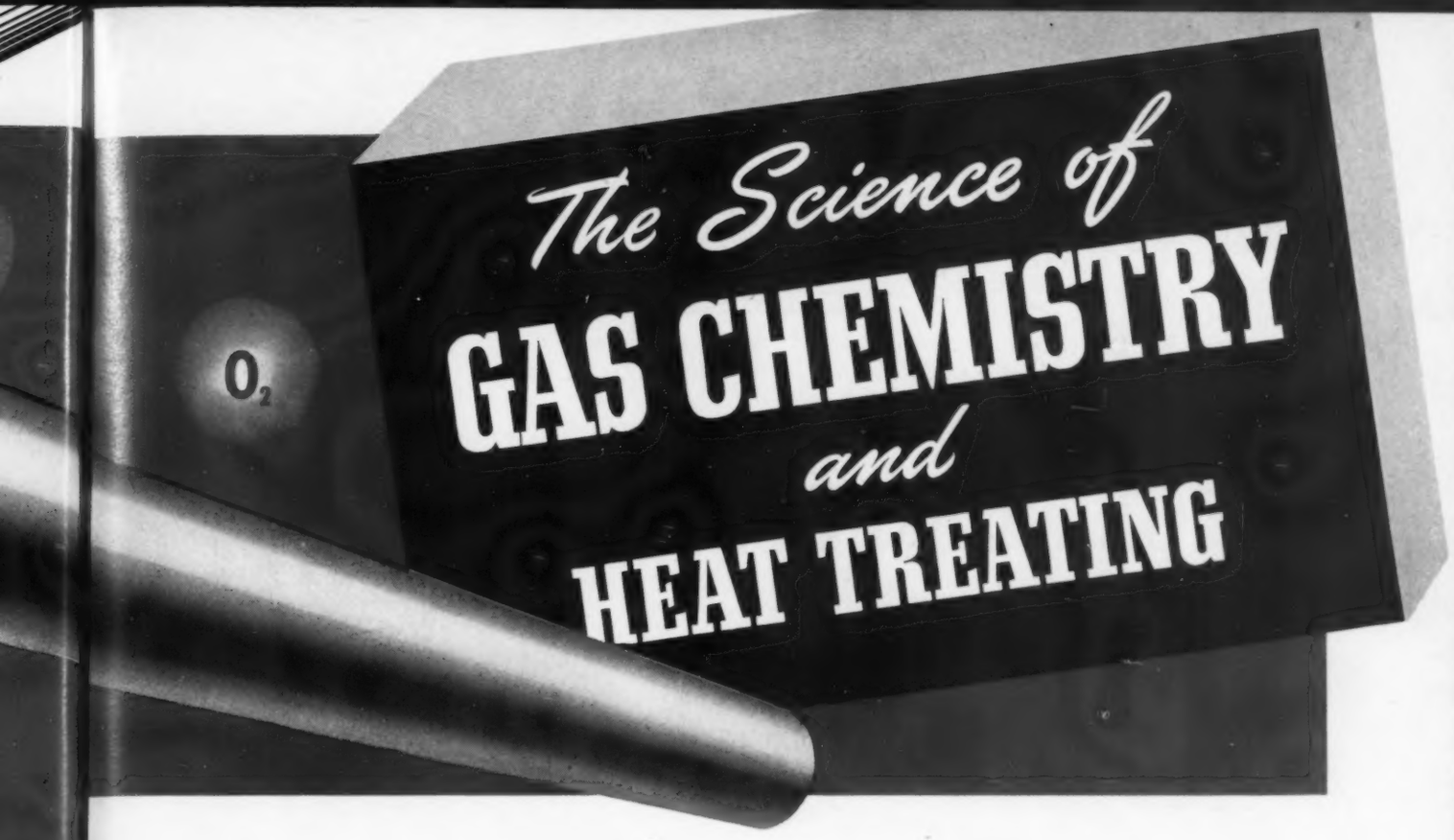
The (SC) Primer of

PREPARED ATMOSPHERES

•

A booklet that compresses into handy form the information that every steel mill heater should have at his finger tips. Write for your copy today.





Surface Combustion research in the use of gases for atmospheres in the heat treatment of metals, has made possible metallurgical results of such significance that it goes far beyond the mechanical details of furnace construction.

Today, with the use of Surface Combustion Radiant Tube Heating Elements and Prepared Atmosphere Generating Units metal surfaces are preserved, including both high and low carbon steels and non-ferrous metals. There are atmospheres to prevent decarburization of steels, and also for recarburization in case the carbon has been removed by an earlier operation. There are surface hardening atmospheres of a number of kinds, and atmospheres for producing specific effects upon metal surfaces.

In addition to these surface treatments, recent developments have shown marked effects of small amounts of gases within the physical structure of metals. Some of these gases are retained from the melting operation and some are entrapped during heat treatment. Some gases cling tenaciously to a metal surface just short of chemical union, while others are readily driven off into the surrounding medium. It is desirable to eliminate harmful reactions between metals and gases, and to develop superior metallurgical properties here-to-fore unknown. Gas quenching and dry pickling are recent outstanding Surface developments embracing the science of gas chemistry and heat treating, that have been industry proven. Other major developments are in the making.

Surface believes that great advancements in metallurgical treatment will come from the application of gas chemistry...that many post-war heat treating problems will be approached from new scientific angles that will give superior results at new low production costs.

The Heater's and Heat Treater's Helping Hand

'Surface'

SURFACE COMBUSTION • TOLEDO 1, OHI

WHEREVER HEAT IS USED IN INDUSTRY
...FROM INGOT TO FINISHED PRODUCT

A SINGLE OBJECTIVE.....

Production Control

A SINGLE RESPONSIBILITY IN ACHIEVING IT

Higher tonnage and uniform quality of product result from efficient control of steel mill equipment. An invaluable aid in achieving this is a system of automatic controls and instruments that allows operators to concentrate on the factors making for optimum production. To secure these results, Republic Flow Meters Co. offers a complete manufacturing and engineering service—a single responsibility—in the field of measurement and control. We will gladly co-operate with you in the solution of any metering or control problem. Your inquiries involve no obligation.

FURNACE CONTROLS
For furnace pressure, fuel, fuel-air ratio.

BOILER CONTROLS
For all boilers, all types of firing.

REGULATORS
For pressure, flow, speed, level, ratio.

GAS MIXER CONTROLS
For mixing gases in desired ratio.

COKE OVEN GAS CONTROLS
For collecting mains, stack draft, pressures.

RING-BALANCE METERS
For steam, water, gas, air, oil, etc.

ELECTRICAL FLOW METERS
For steam, water, gas, air, oil, etc.

FURNACE PRESSURE RECORDERS
For pressure in all types of furnaces.

DRAFT & PRESSURE INDICATORS
For draft, pressure, flow, temperature, CO_2, etc.

THERMOMETERS
For temperatures up to 1000 F.

DATA BOOKS MAILED ON REQUEST

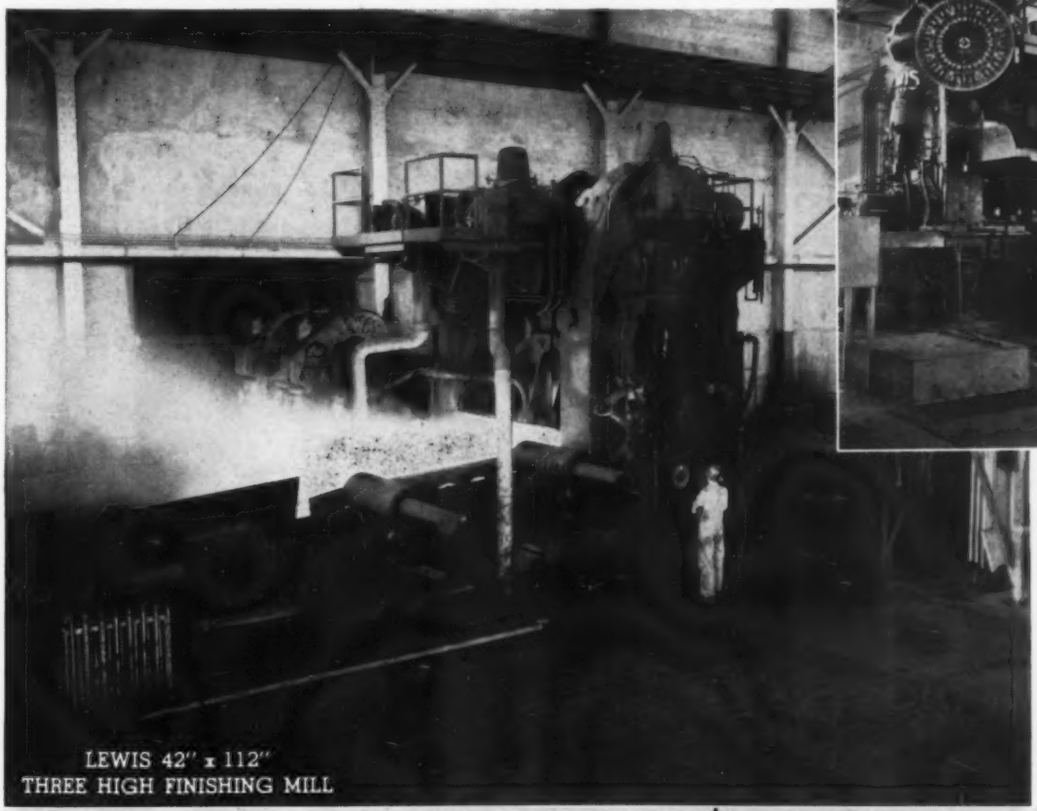
REPUBLIC FLOW METERS CO.
2220 Diversey Parkway, Chicago, Illinois

New *LEWIS MILL* Speeds Plate Production for Victory Ships

Lewis Foundry and Machine Division is proud of this opportunity to help speed up production of Victory ships through the design and production of a complete rolling mill for ship plates in the remarkable time of fourteen months from initial design to operation.

The equipment includes: Vertical Edger, Two High Reversing Mill, Three High Finishing Mill, Ingot Buggy, Approach-Delivery and Transfer Tables, Dividing Shear, End Shears, Side Trimmer Shear, Light and Heavy Roller Levelers, Inspection Tables, Roll Lathe and Rolls.

This accomplishment is a typical example of the high quality of Lewis service which has long been recognized by operators of steel and non-ferrous rolling mills. Lewis rolls and rolling mill machinery have contributed their part to the international growth of rolled products from the very beginning.



LEWIS 42" x 112"
THREE HIGH FINISHING MILL

This Lewis two high reversing breakdown mill rolls 44" x 110", 1/4" to 1" finished plate up to 100" width.

LEWIS

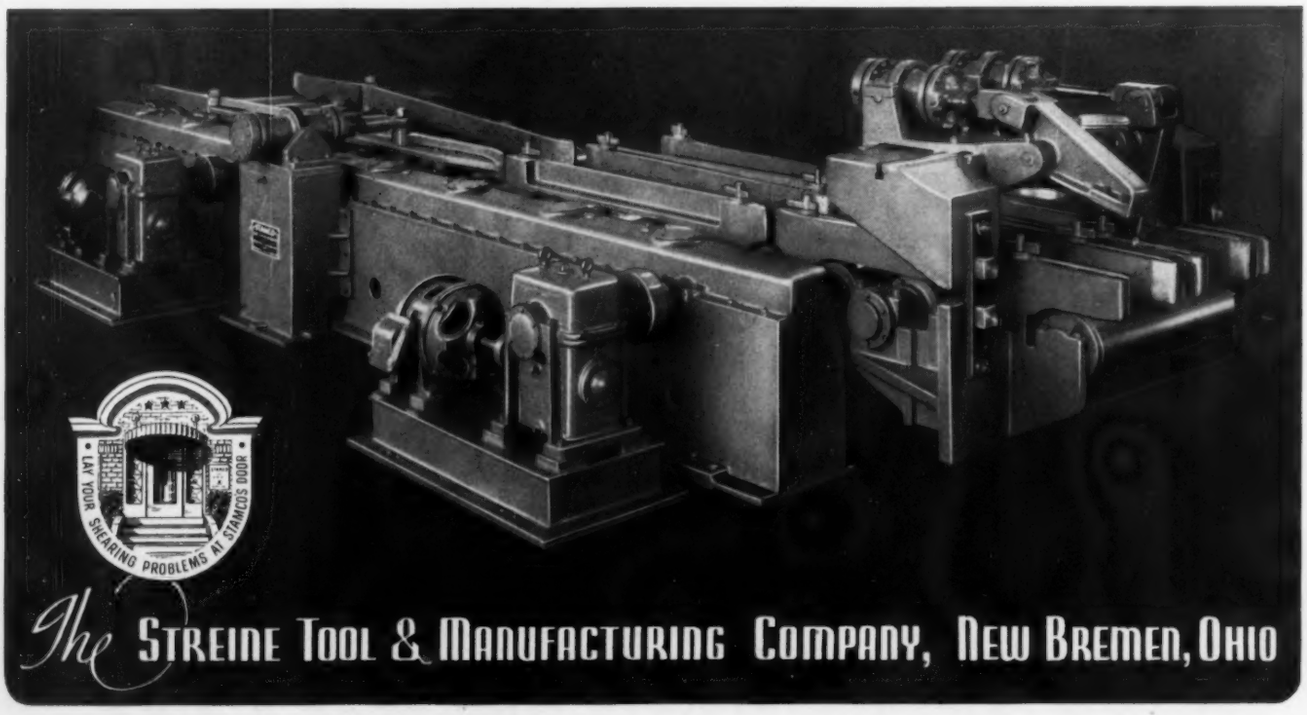
LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX CO.

PITTSBURGH, PA.

STAMCO

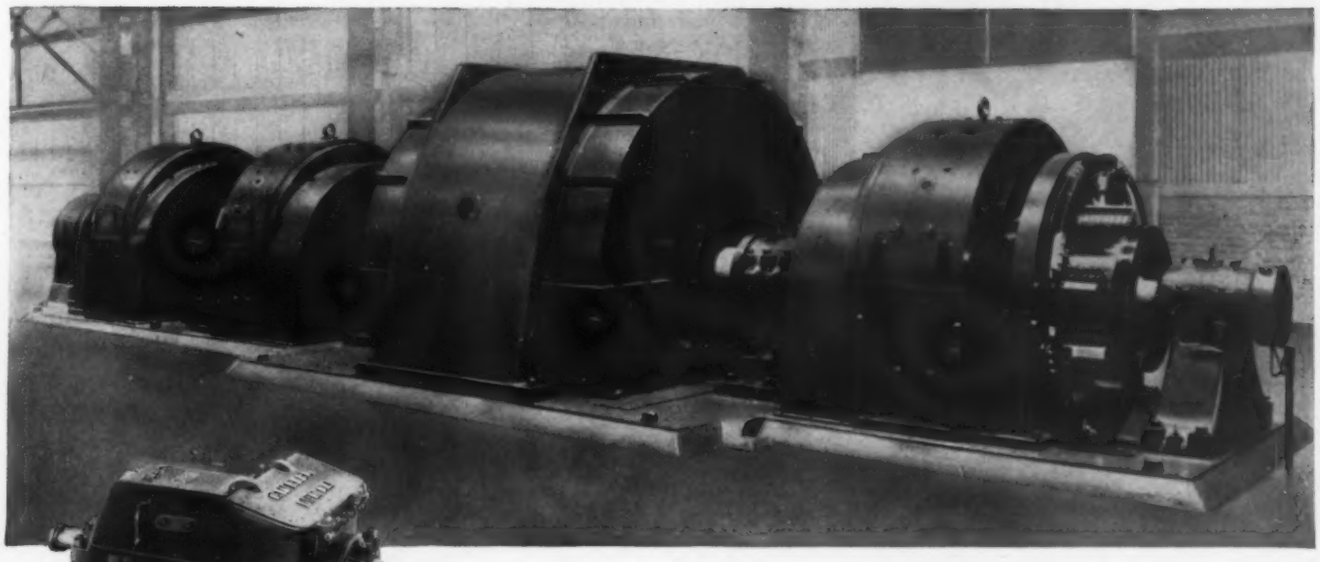
Special Heavy Duty Mill Type Tables

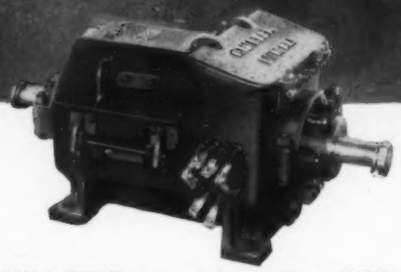


The STREINE TOOL & MANUFACTURING COMPANY, NEW BREMEN, OHIO

CROCKER-WHEELER POWER

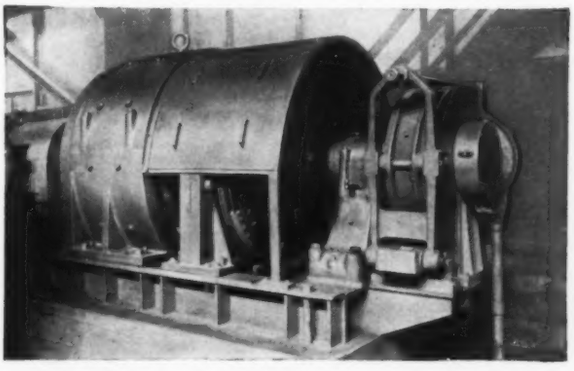
...for the modern Plate Mill



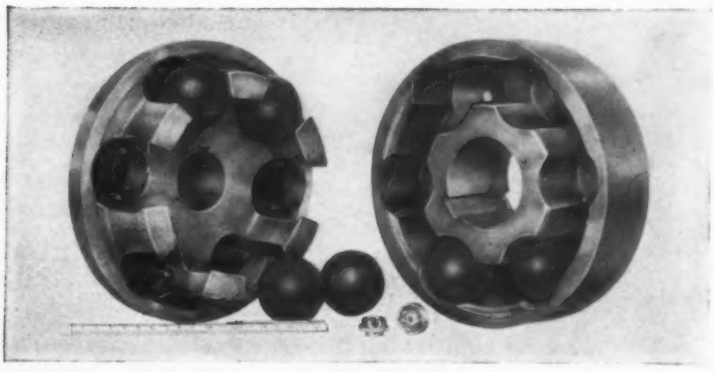


MILL TYPE d-c motors, 5 to 150 hp., with or without interpoles.

DC power supply for a modern mill, consisting of two 1250 kilowatt, 600 volt d-c generators and one 1,000 kilowatt, 250 volt d-c generator, all driven by a 4,800 kilovolt-ampere, 6,600 volt, 25 cycle, 3 phase synchronous motor. All machines are arranged for forced ventilation from a source of cool, clean air, exhausted into the room. The air intake and filter can be seen in the background.



"TAILORED" d-c drives for important auxiliaries such as the 700 horsepower, 500 rpm slab squeezer drive motor above provide the flexibility of power and speed necessary for maximum production.



CUSHIONPOWER couplings, resilient under load, provide protection for bearings by cushioning load shocks as well as by absorbing misalignment stresses. The large coupling illustrated above is ideal for use on all heavy duty plate mill applications.

JOSHUA HENDY IRON WORKS

CROCKER-WHEELER DIVISION

ESTABLISHED 1856

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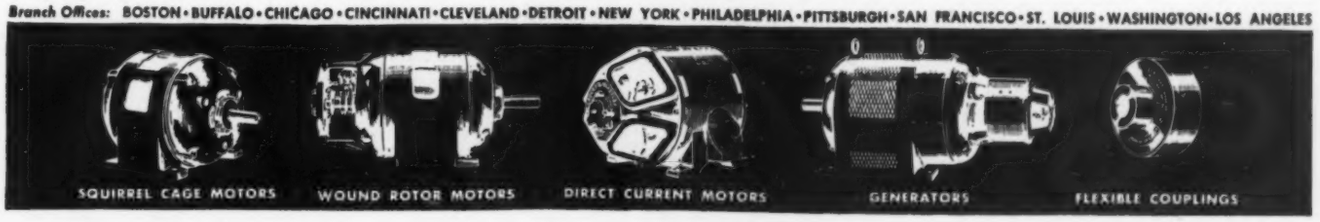
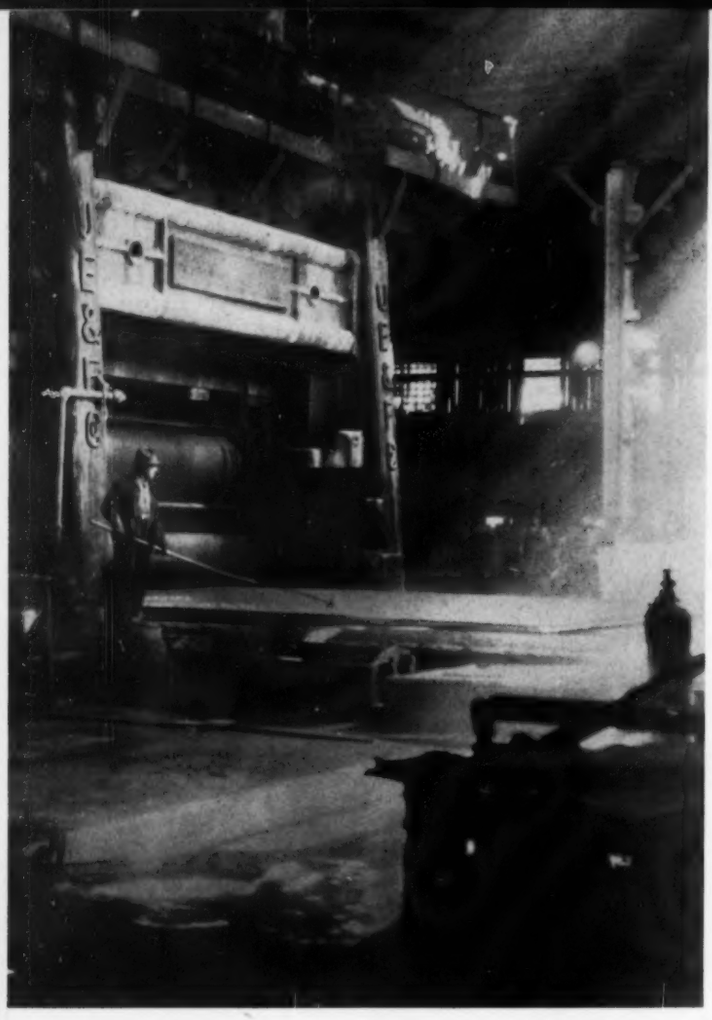




THE *Modern Plate Mill*

. . . . continuing its survey of rolling mill equipment, the Association of Iron and Steel Engineers, through its Rolling Mill Committee, presents data on the modern plate mill . . . . departing from the previous plan of a single complete article, plate mills are here covered by a group of separate papers presented before the district sections of the Association . . . .

▲ FROM understudy to prima donna of the steel industry is the Cinderella fable of the plate mill during the past two years. With Mars calling the tune, plate production has grown to some five or six fold of previous normal figures, just another of the impossibilities which American industry has accomplished.

By the trade definition, plates comprise that group of flat hot-rolled finished steel products which includes:

3/16 in. (7.65 lb per sq ft) or thicker, over 48 in. wide.

1/4 in. (10.2 lb per sq ft) or thicker, over 6 in. wide.

Flat hot-rolled steel products that are within these size ranges, but not classed as plates, include slabs, sheet bar and skelp.

From the foregoing definition, it is apparent that plates may be rolled on a wide variety of mills, such as blooming and slabbing mills, sheet bar and skelp mills, continuous strip mills, semi-continuous plate mills, jobbing mills, sheared plate mills and universal plate mills. Indeed, the accompanying tabulations of the plate production facilities of the United States, as prepared from War Production Board listings, show every one of these mill types.

An inspection of Table I shows that most of the sheared plate mills are of the single stand, three-high type, with middle roll diameters about two-thirds that of the top and bottom rolls. The largest of the three-high mills is 164 in. wide. More recently the four-high mill has been favored, as it has demonstrated its ability to roll a more uniform gauge from edge to center. The four-high mills, of course, require a reversing drive, but eliminate the tilting tables of the three-high. The largest four-high mill is 206 in. wide.

Further inspection of recent installations shows a pronounced trend to the two-stand tandem mill, thus separating the roughing and finishing operations and resulting in a better surface quality. Such units are better adapted to the thinner gauges and are capable of greater tonnages than the single stand mill.

TABLE I — Sheared Plate Mills

Company	Location	Number of stands	Type	Roll diameter, in.	Roll length, in.	Gauges, in. (Based on shearing capacity)	Maximum width, in.	Annual capacity, net tons	Drive: Type	Drive: Hp	Drive: Rpm	Rpm of rolls
Alan Wood Steel Company	Ivy Rock, Pennsylvania	2	3-high	30 & 18	84	3/16–3/4	72	145,600	Ind. motors (Two)	2500	257	63.6 & 70.7
Allegheny-Ludlum Steel Corporation	Brackenridge, Pennsylvania	1	3-high	30	110	1 1/2 max	80	85,000				
American Rolling Mill Company	Middletown, Ohio	1	2-high		96①	5/8 max.	90	42,000	Ind. motor	1000	368	43
Bethlehem Steel Company	Sparrows Point, Maryland	1	3-high	44 & 27 1/2	160	Up to 2	150	288,000	Ind. motor	4500	370	37.5
	Sparrows Point, Maryland	1	3-high	38 & 24	114	Up to 2	100	240,000	Ind. motor	4000	83	83
	Johnstown, Pennsylvania	1	3-high	36 & 22	134	5/16–2	120	288,000	Steam eng.	2400	50– 70	50– 70
A. M. Byers Company	Ambridge, Pennsylvania	1	2-high	32	96②	3/4 max.	84	24,000	Rev. motor	4000	60–140	60–140
Carnegie-Illinois Steel Corporation	Gary, Indiana	1	3-high	44 & 28	164	Up to 2	146	360,000	Ind. motor	7000	83.3	83.3
	Homestead, Pennsylvania	1	3-high	38 3/4 & 22 3/4	141	Up to 2	128	430,000	Steam eng.	2250		
Central Iron and Steel Company	Harrisburg, Pennsylvania	1	3-high	34 & 21	126	5/16–2	115	138,000	Steam eng.	1500	70	47
	Harrisburg, Pennsylvania	1	3-high	28 & 17 1/2	89	No. 12–1/2	72	48,000	Steam eng.	1200	70	55
Crucible Steel Company of America	Pittsburgh, Pennsylvania	1			87①	Up to 1	60	6,000				
Defense Plant Corporation	Homestead, Pennsylvania	2	2-high	36	70		150	500,000	Ind. motor	1600	492	
			4-high	39 & 38	160				Rev. motors (Two)	5000	40–80	40–80
Henry Disston and Sons, Inc.	Philadelphia, Pennsylvania	3	2-high	28	84	.1–1.0	76	5,000	Steam eng.	300	62	62
Borg-Werner Corporation	New Castle, Indiana				60			6,000				
Inland Steel Company	Indiana Harbor, Indiana	1	3-high	33 & 22	103	Up to 2	90	264,000	Ind. motor	2000	244	36.4
Jessop Steel Company	Washington, Pennsylvania	1	2-high	30	84	1/16–1	72	12,000	Motor	1400	38	
	Washington, Pennsylvania	1	2-high	28	76	02–5/8	60	8,500	Steam eng.	800	42	
Jones and Laughlin Steel Corporation	Cleveland, Ohio	1	3-high	42 & 26	152	Up to 2	144	138,000	Steam eng.	2500	69	69
Kaiser Company, Inc.	Fontana, California	2	2-high	44	112	5/16–2	96	360,000	Rev. motors (Two)	3500	30–75	30–75
			3-high	40 & 26 1/2	110				D-c motors	7000	50–120	50–120
Lukens Steel Company	Coatesville, Pennsylvania	2	3-high	38 & 22	140	Up to 2	195	360,000	Steam eng.			
			4-high	50 & 34	206				Steam eng.			
	Coatesville, Pennsylvania	2	3-high	36 & 22	112	Up to 5/8	110	300,000	Ind. motor	3750	500	
			4-high	54 & 36	120④				Rev. motor	7000	35–80	35–80
	Coatesville, Pennsylvania	2	2-high	34	84	Up to 5/8	72	84,000	Rev. motor	2500	53–80	53–80
			4-high	40 & 23	84				Rev. motor	1600	25–50	25–50
Pine Iron Works	Pine Forge, Pennsylvania	1	2-high	28	84	Up to 5/8	60	10,000				
Republic Steel Corporation	Gadsden, Alabama	1	3-high	32 & 22	112③	Up to 2	104	210,000	D-c motor	4000	80–160	80–160
	Canton, Ohio	1	2-high	30	76①	1/2 to 2	68	60,000	Driven from sheet mill train			
	Canton, Ohio	1	2-high	28	60①	1/16–2	54	60,000	Ind. motor	1200		
	Canton, Ohio	1	3-high	32	60①	1/4–1 1/4	48	60,000				
Sheffield Steel Corporation	Kansas City, Missouri	2	3-high	32	84①	3/8	72	12,000				
	Houston, Texas	1	3-high	40 & 24	110	5/16–1 1/2	100	180,000	Ind. motor	3000		
	Houston, Texas	1	3-high	34 & 22	112	5/16–1 1/2	100	72,000	Ind. motor	1500	240	26.5
	Houston, Texas	1	3-high	32 & 22	84①	5/16–1 1/2	72	60,000	Driven from 1500 hp motor listed above.			
Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	2	3-high	36 & 24	110	5/16–2	128	360,000	Ind. motor	4000	82	82
			4-high	36 & 38	140				Rev. motor	7000	35–70	35–70
Worth Steel Company	Claymont, Delaware	1	3-high	44 & 27	160	Up to 2	144	162,000	Steam eng.	5300	68	36.6
	Claymont, Delaware	1	3-high	42 & 25	120	5/16–1/2	100	108,000	Ind. motor	4000	200	42.2
								5,486,100				

①Jobbing mill. ②Convertible to universal mills.
④This unit installed by United States Navy. An integral edger on the 120 in. stand and a separate edger enable this unit to produce universal plate.

TABLE II — Universal Plate Mills

Company	Location	Number of stands	Nominal mill size, in.	Roll diameter, in.	Roll length, in.	Gauges, in. (Based on shearing capacity)	Maximum width, in.	Annual capacity, net tons	Drive: Type	Drive: Hp	Drive: Rpm	Rpm of rolls
Bethlehem Steel Company	Sparrows Point, Maryland	One, 2-high	60	36	84	Up to 2	58	288,000	Rev. motor	4400	50–100	50–100
	Johnstown, Pennsylvania	Three, 2-high	36	24	67 & 57	1/8–2	36	150,000	Steam eng.	3600	70–100	70–100
									Ind. motor	1800	75	75
	Seattle, Washington	Four, 3-high	22			Up to 2	20	42,000	Ind. motor	2400	505	
Carnegie-Illinois Steel Corporation	Homestead, Pennsylvania	One, 2-high	48	31	88	Up to 2	48	240,000	Steam eng.	1500		
	South Chicago, Illinois	One, 2-high	30	24	67	2	30	230,000	Rev. motor	4000	70–150	70–150
	Gary, Indiana	One, 3-high	60	36	84	1/4–2	60	240,000	Ind. motor	4500–6500	53–107	53–107
Central Iron and Steel Company	Harrisburg, Pennsylvania	One, 2-high	42	25	50	2	42	90,000	Steam eng.	2500	83	83
Inland Steel Company	Indiana Harbor, Indiana	Two, 2-high	24	25	60	2	26	98,000	D-c motor	3000	175	175
				24	44							
Lukens Steel Company	Coatesville, Pennsylvania	One, 3-high	48	26 & 21	66	2	48	84,000	Steam eng.			
Republic Steel Corporation	Youngstown, Ohio	One, 3-high	60	32 & 22	84	1	58①	60,000	D-c motor	3330	94–160	
Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	One, 3-high	42②	30 & 21	65	2	45	48,000	D-c motor	4000	80–160	80–160
								1,570,000				

①Up to 72 in. on sheared plate.
②This mill serves as a rougher for 48 in. continuous strip mill.

TABLE III — Continuous Strip and Plate Mills

Company	Location	Mill size, in.	Gauges, in. (Based on shearing capacity)	Maximum width, in.	Annual plate capacity, net tons
Acme Steel Company	Chicago, Illinois	24	.....	.....	18,000
Allegheny-Ludlum Steel Corporation	Leechburg, Pennsylvania	16	Up to 1/2	20	120,000
American Rolling Mill Company	Middletown, Ohio	80*	Up to 1/4	60	54,000
	Ashland, Kentucky	58*	Up to 3/8	51	180,000
Bethlehem Steel Company	Lackawanna, New York	79*	Up to 1 1/2	72	750,000
	Sparrows Point, Maryland	56*	Up to 1/2	48	60,000
Carnegie-Illinois Steel Corporation	Homestead, Pennsylvania	110*	Up to 1 1/2	100	840,000
	South Chicago, Illinois	96*	Up to 1 1/4	85	624,000
	Dravosburg, Pennsylvania	80*	Up to 3/4	73	950,000
	Gary, Indiana	80*	Up to 1	73	480,000
	Gary, Indiana	38*	Up to 5/8	32	72,000
	Gary, Indiana	20	Up to 3/4	18	36,000
	Gary, Indiana	12	Up to 5/8	9	48,000
	McDonald, Ohio	43*	Up to 3/8	36	192,000
Ford Motor Company	Dearborn, Michigan	64*	Up to 2	58	150,000
Geneva Steel Company (D.P.C.)	Geneva, Utah	132	Up to 1 1/2	120	840,000
Granite City Steel Company	Granite City, Missouri	90*	Up to 1	84	156,000
Great Lakes Steel Corporation	Detroit, Michigan	96*	Up to 1/2	90	720,000
	Detroit, Michigan	38*	Up to 3/8	30	144,000
Inland Steel Company	Indiana Harbor, Indiana	76*	Up to 5/8	72	540,000
	Indiana Harbor, Indiana	44*	Up to 1/2	42	12,000
Jones and Laughlin Steel Corporation	Pittsburgh, Pennsylvania	96*	Up to 3/4	90	600,000
	Cleveland, Ohio	77*	3/4	72	360,000
	Cleveland, Ohio	30	1/2	26	54,000
Republic Steel Corporation	Cleveland, Ohio	98*	3/4	90	950,000
	Warren, Ohio	42*	3/4	36	60,000
	Warren, Ohio	14	1/2	11	12,000
Weirton Steel Company	Weirton, West Virginia	18	1/2	22	30,000
Wheeling Steel Company	Steubenville, Ohio	66*	1/4	54	120,000
Youngstown Sheet and Tube Company	Youngstown, Ohio	79*	1	72	420,000
	East Chicago, Indiana	54*	3/8	51	72,000
					9,664,000

*For complete description see "The Modern Strip Mill."

Table I also includes a number of units termed jobbing mills which vary from simple two-high hand mills to three-high stands equipped with automatic feeder and catcher tables, screwdown, etc.

The tabulation of universal mills (Table II) shows the maximum width to be 60 in. These units are about evenly divided between two-high and three-high design. In some cases, the vertical rolls may be removed from the universal mills, allowing them to roll sheared plate of greater widths. Universal plate, with its rolled edges eliminating side trimming, usually gives 5-8 per cent better yield than is obtained with sheared plate.

Table III lists the continuous strip and plate mills, comparative newcomers to the industry which have made possible our record plate productions. The important contribution of the conversion of these mills to plate production is amply indicated by Table IV which shows monthly productions of the various types of mills since the last quarter of 1941. Mills of this type are acknowledged to be the last word in rolling large tonnages of light plate material, but involve a heavy initial investment and to some extent lack flexibility for small orders of various sizes. A goodly number of the mills listed in Table III do not have all that might be desired in the way of layout and equipment for plate production — indeed, should not be classified permanently as plate producers. Such companies, however, with characteristic ingenuity and patriotism, have nevertheless done much to bring plate production up to requirements.

Table V lists various other mills included in WPB plate capacity tabulations. The size limitations of these mills are at once apparent. There are other similar mills in the country which can show equal claims for inclusion in plate facilities.

Combining the capacities of the various mills tabulated here, we find a grand total of 17,080,100 tons of plate per year, considerably higher than the tabulated production figures. All of this capacity, however, has not yet made itself felt in production figures. Some of it has been in production less than a year, some has just begun, and still more of it is producing armor plate which is not included in the tabulated production figures. There have also been few times when tonnage allocations to the mills called for full capacity operation of all units. Some mills are producing in excess of their tabulated capacity, others considerably below.

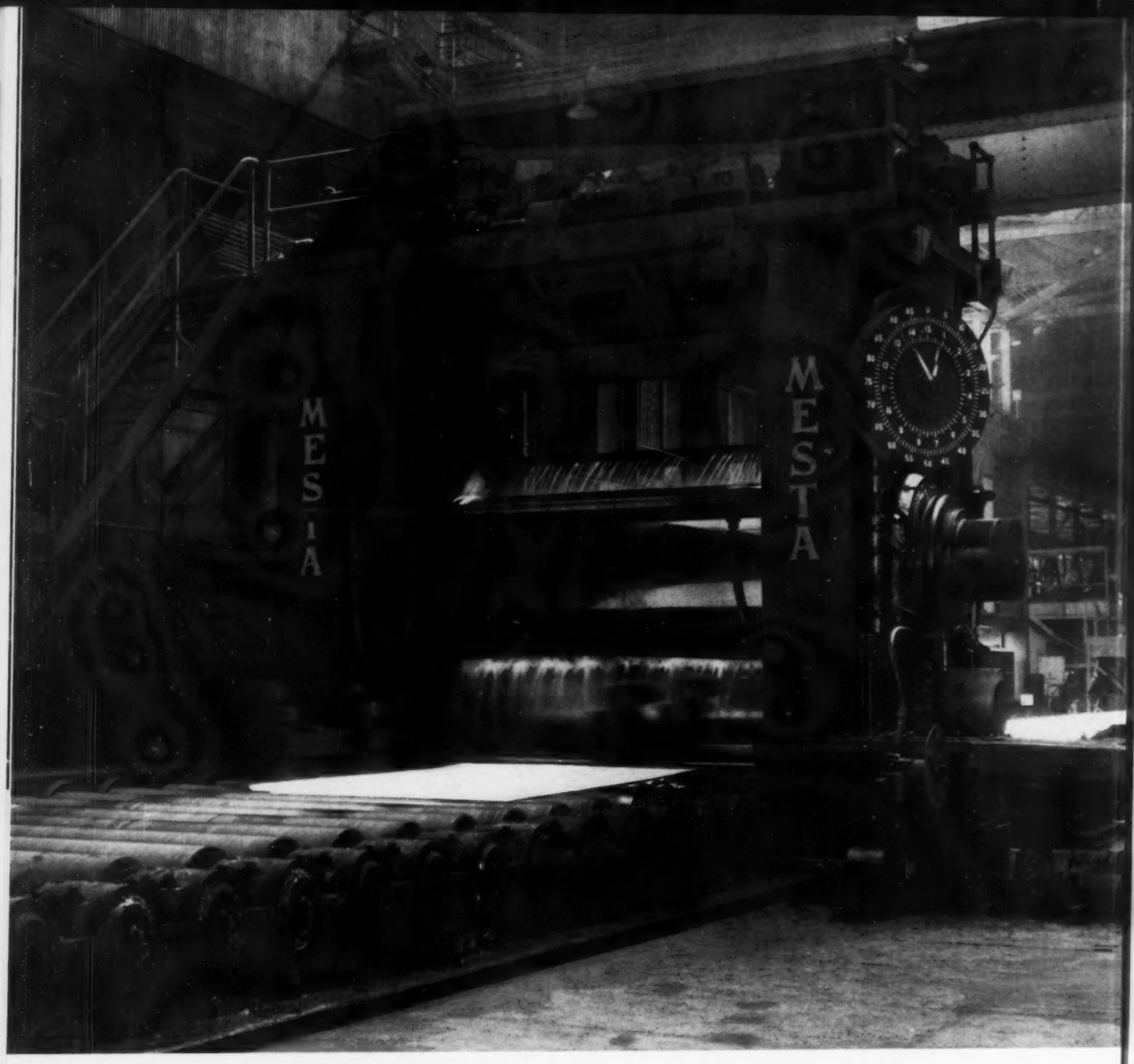
With these brief remarks concerning the plate facilities of the United States, we introduce comprehensive discussions of plate mill design and operation in the following papers by Messrs. Noble, Bunting, Watson, Moses and Fisher.

TABLE IV — Plate Shipments

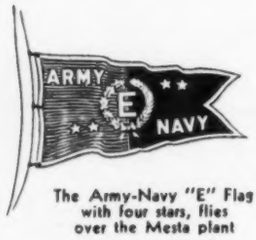
Month	Universal mill		Sheared mill		Strip mill		Total net tons
	Net tons	Per cent of total	Net tons	Per cent of total	Net tons	Per cent of total	
1941							
October	94,311	15.9	346,401	58.4	152,440	25.7	593,152
November	998,828	16.1	350,868	56.6	169,311	27.3	620,007
December	113,467	17.3	358,273	54.8	182,604	27.9	654,344
1942							
January	122,227	16.2	381,899	50.6	250,396	33.2	754,522
February	111,965	14.8	377,770	49.8	268,988	35.4	758,723
March	123,152	14.1	449,379	51.1	306,195	34.8	878,726
April	121,838	13.6	436,614	48.7	337,519	37.7	895,971
May	125,608	12.4	461,375	45.6	425,211	42.0	1,012,194
June	123,114	11.7	438,144	41.7	489,704	46.6	1,050,962
July	126,100	11.2	447,481	39.8	550,537	49.0	1,124,118
August	115,710	10.5	430,197	39.2	551,959	50.3	1,097,866
September	115,372	10.9	434,555	40.9	511,909	48.2	1,061,836
October	114,506	10.4	449,895	40.8	536,981	48.8	1,101,382
November	114,755	11.3	424,708	41.9	474,136	46.8	1,013,599
December	114,650	10.8	454,902	42.9	490,487	46.3	1,060,039
1943							
January	121,039	10.7	448,481	39.5	565,893	49.8	1,135,413
February	118,519	11.0	424,167	39.6	529,315	49.4	1,072,001
March	138,805	11.9	465,572	39.9	563,302	48.2	1,167,679
April	131,272	11.7	454,827	40.5	535,548	47.8	1,121,647
May	119,332	10.7	460,060	41.3	535,528	48.0	1,114,920
June	115,986	11.0	431,565	40.9	508,534	48.1	1,056,085
July	121,059	11.1	438,066	40.2	530,552	48.7	1,089,677
August	124,315	11.7	439,358	41.4	497,263	46.9	1,060,936
September	121,929	11.0	444,585	40.2	540,337	48.8	1,106,851
October	127,751	11.1	463,250	40.4	555,844	48.5	1,146,845
November	135,999	11.9	463,656	40.6	541,485	47.5	1,141,140
December	130,573	11.2	474,122	40.5	564,501	48.3	1,169,196

TABLE V — Other Mills Listed for Plate Production

Company	Location	Mill size and type	Maximum gauge, in.	Maximum width, in.	Annual capacity, net tons
Andrews Steel Company	Newport, Kentucky	24 in. sheet-bar mill	....	....	6,000
Atlantic Steel Company	Atlanta, Georgia	25 in. blooming mill	1½	10	6,000
Bethlehem Steel Company	Steelton, Pennsylvania	22 in. bar mill	1	14	36,000
	Johnstown, Pennsylvania	14 in. bar mill	1	8	24,000
Carnegie-Illinois Steel Corporation	Clairton, Pennsylvania	18 in. bar mill	¾	10	60,000
	McDonald, Ohio	18 in. bar mill	....	....	6,000
	Gary, Indiana	14 in. bar mill	....	....	6,000
Colorado Fuel and Iron Corporation	Pueblo, Colorado	20 in. bar mill	....	....	6,000
	Pueblo, Colorado	25 in. structural mill	....	....	6,000
Crucible Steel Company of America	Pittsburgh, Pennsylvania	24 in. bar mill	1½	28	6,000
Great Lakes Steel Corporation	Detroit, Michigan	21 in. bar mill	....	....	12,000
	Detroit, Michigan	14 in. bar mill	1	12	24,000
Jones and Laughlin Steel Corporation	Aliquippa, Pennsylvania	14 in. bar mill	2	15	12,000
Republic Steel Corporation	Cleveland, Ohio	12 in. bar mill	1½	8	6,000
Sheffield Steel Corporation	St. Louis, Missouri	24 in. bar mill	1½	8	6,000
Tennessee Coal, Iron and Railroad Company	Bessemer, Alabama	16 in. bar mill	1	14	18,000
Weirton Steel Company	Weirton, West Virginia	18 in. bar mill	1¼	12	30,000
Wisconsin Steel Works	S. Chicago, Illinois	27 in. bar mill	2	30	66,000
Youngstown Sheet and Tube Company	East Chicago, Indiana	21 in. bar mill	2	22	24,000
					360,000



140" FOUR HIGH REVERSING PLATE MILL
DESIGNED AND BUILT BY MESTA



The Army-Navy "E" Flag
with four stars, flies
over the Mesta plant

ONE OF THE MODERN

FOUR HIGH REVERSING PLATE MILLS

BUILT BY

MESTA

MESTA MACHINE CO
PITTSBURGH, PA.

★ ★ LET'S ALL BACK THE ATTACK — BUY MORE WAR BONDS ★ ★

RECENT *Plate Mill* *Developments*

by R. E. Noble

ROLLING MILL ENGINEER

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

DAN REEBLE PHOTO

▲ SOME twenty-four hundred years ago the Greeks of ancient Athens in a time of dire national emergency had received this somewhat obscure advice from the Delphian oracle: "When everything else in the land of Hellas shall be taken, the wooden walls alone shall remain unconquered to defend you and your children." This was interpreted to mean that the Athenians should take refuge within the "wooden walls" of their ships. Consequently they abandoned their cities to the torches of the Persian invaders and, entrusting their fortunes to the fleet, won the decisive naval battle of Salamis and turned back the Persian hordes.

When Japan unleashed her foul attack at Pearl Harbor, America swiftly abandoned the delusive idea held by some of fighting a defensive war in her own territory and launched out upon the seven seas to carry the war to the enemy. The cry came for ships and more ships and it soon became apparent that the physical safety of America lay not in "wooden walls" but in the "steel shells" of her navy and merchant marine.

The production of steel plates in the United States had risen from a depression low of under a million tons in 1932 to a recovery peak of over three and a half million in 1937, then had slumped to under two million in 1938 and by the end of 1941, under the impetus of the war in Europe and the defense program at home, had climbed again to an all-time high of over six million tons. But this was only the beginning. During the single year of 1942 the record tonnage of 1941 was almost doubled, reaching the amazing total of over 11,800,000 tons for the year and that without benefit of more than a relatively small increase in new rolling capacity. The record for 1943 has not been completed but the figures for the first ten months of the year indicate that the total will be pretty close to 13,500,000 tons. This phenomenal increase in plate production is shown graphically in the chart of annual production, Figure 1, plotted from the published production figures of the American Iron and Steel Institute.

It is of course not likely that the astounding rate of

Presented before A. I. S. E. Pittsburgh District Section Meeting, December 13, 1943

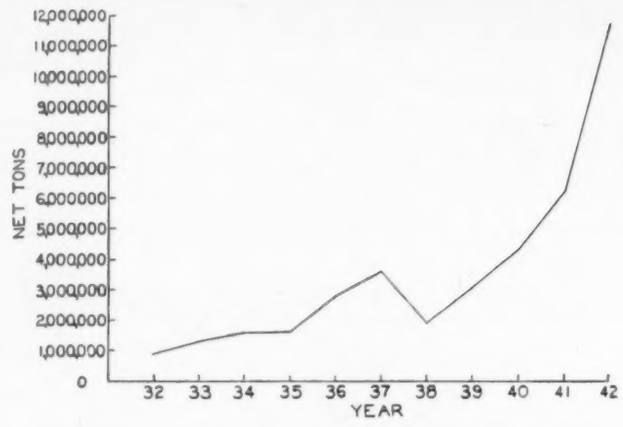


Figure 1 — Chart showing total annual plate production of the United States, 1932-1942 inclusive.

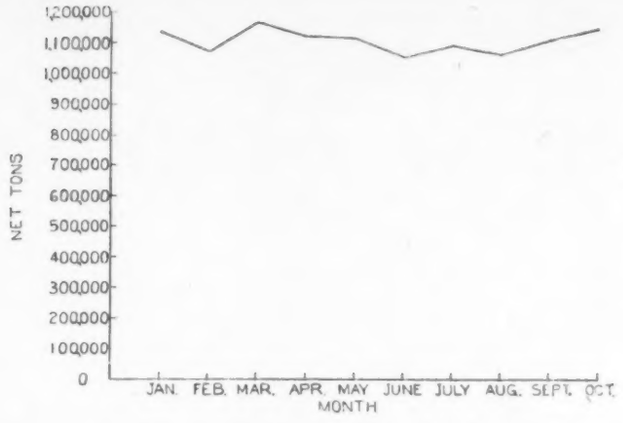


Figure 2 — Chart showing total plate production of the United States for 1943, month by month.

increase that has prevailed for the past several years will be continued through another year but we may expect a decided flattening out of the curve. The fact that this is even now happening is shown by the monthly production figures for the past ten months of 1943 (see Figure 2). However, it is well to bear in mind that we have in the new productive capacity that is just coming into operation, or will come into operation early in 1944, a sizable strategic reserve of rolling capacity that will help to guarantee, in spite of the present continuing tightness in the plate situation, that the steel industry of the United States will be able to meet all the demands with respect to plates that the military situation is likely to put upon it.

It is not the purpose of this paper to dwell long upon the statistical aspect of recent plate production but this brief resume is offered merely as an introductory background for a paper that is intended to be mainly descriptive of a number of new plate mill installations in this country and in two or three of our neighboring or allied lands. Several of these have been in operation for a period of some months or have just recently come into operation and several promise to be in full operation in the near future. However before leaving the subject of the very rapid increase in plate production during the last three or four years it may be well to mention and evaluate some of the factors that have contributed to this gratifying result.

The graphs shown in Figure 3 were also plotted from the 1942 annual statistical report of the American Iron and Steel Institute. There was a rapid and steady increase through the years of 1939 and 1941 inclusive in practically all categories of flat rolled steel products but 1942, the first year of our participation in the war, produced a decided change in the trends of the different items that go to make up the total. The total of all hot rolled iron and steel products in 1942 was only a small fraction of one per cent higher than in 1941. The total of all wide flat rolled products not including skelp actually declined about 3 per cent. The output of all classes of wide flat rolled products other than plates declined sharply without exception but the production of plates nearly doubled under the urgent demand for naval and maritime plates, tank plates and light armor. What was happening as America was girding herself to beat her plowshares into swords? The largest single item of flat rolled steel in recent years has been sheets, accounting in 1941 for about 43 per cent of the total. While the production of plates was rising by the amount of 5,600,000 tons, the production of sheets declined 4,400,000 tons and the other classes of flat-rolled products followed suit. Apparently the temporary sacrifice of our automobiles, electric refrigerators and other gadgets to Mars has proved to be well worth while.

We have again plotted in Figure 4 the curve of total plate production as shown by the upper curve (A). Under it are plotted two other curves, curve (C) showing the plate production of the continuous mills and curve (B) showing all other plate production consisting mainly of the output of the single stand mills rolling sheared plates and the single stand universal mills. The values plotted in curves (B) and (C) add up to the values of total plate production plotted in curve (A). These figures are also taken from the statistical reports of the American Iron and Steel Institute. It will be noted that curve (B) rises steadily throughout the entire period, while curve (C) rises at a somewhat lower rate of increase through 1941 and then leaps suddenly upward in 1942 as much of the continuous mill tonnage was diverted to plate. In 1938 the continuous mills accounted for only 17½ per cent of the total output while in 1942 this proportion rose to 54 per cent as the plate production of the continuous mills passed that of the older conventional types of plate mills for the first time. The potentialities of the continuous strip mills as plate producers were perhaps not fully realized even by some of those who were most concerned with stimulating plate production. It is a fact that the total 1942 production exceeded by some three or four million tons some of the estimates made only a few months before.

This was exceedingly fortunate for the ship-building program and for our entire war effort, for of the new plate mill capacity projected for the United States in 1941 and 1942 or earlier with an estimated total nominal annual capacity of about 2,500,000 tons, only

one or two units were in operation before the end of 1942.

Naturally when the heavy demand for plate first began to make itself felt, the old style conventional sheared and universal plate mills were first called upon, as the continuous strip mills were quite busy with lighter gauge product. There were about thirty of these mills in existence in the United States with a total of between 40 and 45 stands. The larger part of these were operating as single stand units. There were also two wide semi-continuous mills, one in the Chicago district and one in the Pittsburgh district, which were designed primarily for rolling plate. These two mills have ten stands and seven stands respectively. The tonnage possibilities of all of these mills were well known and as the demand for plate developed every effort was made to make the best possible use of these existing facilities.

The conversion of the strip mills for plate production is a story in itself and can only be touched upon lightly in this paper. It is difficult to make an exact classification but of the twenty-eight continuous strip mills listed in the book entitled "The Modern Strip Mill" published by the Association of Iron and Steel Engineers in 1941, only twelve were arranged with hot beds, side tables, levelers, shearing equipment and other necessary finishing equipment for plates. Two of the twelve were those previously mentioned as having been designed primarily for plates. Of the other ten only four were adequately equipped to produce plates to the width and in the gauges required for the bulk of maritime plates and for other wartime uses. For these mills the problem was one of diversion only rather than of conversion thanks to the foresight of those who were responsible for these installations which were in fact combination mills equally capable of producing high tonnages of strip or plate gauges or both. When the sudden wartime demand came for increased plate production, like the marines, they were always ready. While other mills were inherently capable of rolling plate as well as strip, in laying them out the emphasis had been placed on their ability to handle a considerable tonnage of heavy gauge sheet or the lighter plate gauges and they were not very well equipped to level, shear and handle the medium and heavier gauges. Consequently when faced with the necessity of suddenly diverting a large proportion of their tonnage capacity to the production of plates for the war program there were many problems to be met chiefly in the matter of finding or providing sufficient space and equipment for cooling, leveling, cutting and shipping their potentially large output.

But if these mills found the problems of their finishing departments difficult, still more difficulty was to be expected for those continuous mills which had been designed solely for the production of hot rolled and cold rolled sheets. A typical mill of this type has but two outlets consisting of a straight-away runout table delivering the unsheared product of the mill at high speed to coilers or flat stock over or through the coilers (after having been cut to multiple lengths by a flying shear) to a piler at the end of the runout table. When these mills undertook to produce plate, it was necessary to start from scratch in providing the means for cooling, marking, leveling, cutting and handling the high

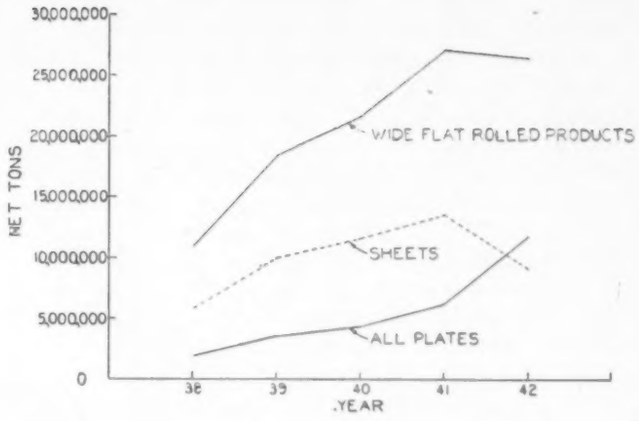


Figure 3 — Chart showing proportion of plate to total wide flat-rolled products, 1938-1942 inclusive.

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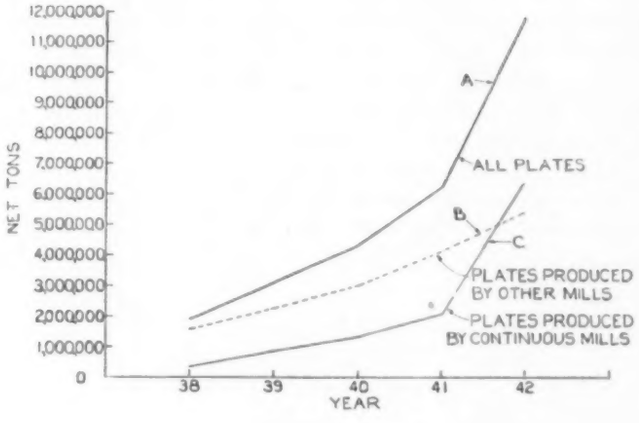
Figure 4 — Chart showing proportion of plate produced by the continuous mills, 1938-1942 inclusive.



tonnage that could be rolled by the mills. Much ingenuity, resourcefulness and energy were displayed in utilizing and revamping old equipment, procuring new equipment and in improvising new arrangements in a very short time. That most of the problems both of diversion and conversion were satisfactorily solved is shown by the great increase in plate tonnage delivered by the continuous mills as a group in 1942.

The successful conversion of the continuous strip mills for plate production did not however entirely meet the needs of the situation although it did serve to tide us over the critical first months of the war. Additional rolling capacity was also needed particularly in the wider widths and heavier gauges. It was necessary to provide not only for our own country but also to assist several of our friends and allies in equipping to produce new or additional plate tonnage. The list of mills recently built or now building in this country

includes three mills for allied countries as will be noted later.

Of the several new installations which will be described in this paper two have been in operation for some months. The single stand 38 in. and 52 in. x 110 in. four-high reversing mill of the Steel Company of Canada at Hamilton, Ontario, went into operation early in 1941 and was the first of the new installations called forth by the war emergency. In May, 1942, the Tennessee Coal, Iron and Railroad Company started a 38 in. and 56 in. x 140 in. four-high reversing mill at their Fairfield Works, Birmingham, Alabama, to serve as a finishing stand behind an existing 110 in. three-high mill. At the same time extensive changes and additions were made to the finishing equipment.

One plate mill on the Pacific Coast was put into operation in August of this year. This is the Kaiser Company's mill at Fontana, California. It consists of a 44 in. x 110 in. two-high roughing stand and a 40 in. and 26½ in. x 112 in. three-high finishing stand.

Another mill which has recently started operations is the 38 in. and 52 in. x 110 in. four-high single stand reversing mill of the South African Iron and Steel Industrial Corporation, Ltd., near Pretoria in the Union of South Africa. While this installation is remote from American industrial centers, it is of interest to us because the mill was built in the United States and much of its product will go into the hulls of ships that will help to keep the flags of the United Nations flying on all the oceans of the world.

Another foreign mill of American make is the 36 in. and 49 in. x 72 in. four-high reversing mill of the National Steel Company of Brazil. This is a single stand mill with vertical edger. It is designed to finish universal plates from reheated slabs and will also supply breakdowns for a continuous hot strip mill.

Returning to the domestic scene, the Sheffield Steel Corporation have at Houston, Texas, two three-high stands, one of which is an existing 40 in. and 24 in. x 110 in. mill which was moved to its present location. The other is a new three-high stand 112 in. wide.

The Lukens Steel Company have extended their facilities by the addition of a 34 in. and 54 in. x 120 in. four-high reversing stand which is being used with an existing 112 in. three-high roughing mill.

A complete 160 in. wide plate mill installation is now being made in the Pittsburgh district, consisting of a 38 in. and 59 in. x 160 in. four-high reversing mill with scale breaker.

The most extensive and complete of the new installations is the high production 132 in. wide continuous mill now being installed in the west.

Of the new mills just enumerated, those within the United States should add nearly 20 per cent to the plate rolling capacity of the country. They are all 110 in. or wider with a range of width to 160 in. and cover a thickness range from 3/16 in. to the heaviest plate rolled. They will therefore form a very effective complement to the capacity now existing in the continuous strip mills and older conventional type plate mills of the country, the tonnage possibilities of which seem by this time to have been pretty well explored.

TYPES OF MILLS

Before proceeding to a more detailed description of the recent mill installations with their component parts and various functional elements, it may be well to discuss and compare briefly the different types of mills that are now used to roll plate and to put them in their proper historical perspective.

At the beginning of the present emergency nearly all of the plate mills in this country, excluding the strip mills and with two or three other notable exceptions, were two high and three high mills. Of the two-high stands only one is wider than 84 in. None of the three-high stands are narrower than 84 in. The mills equipped for rolling universal plate consisted of two-high or three-high horizontal stands with vertical edging rolls mounted as closely as possible to the horizontal rolls. Most of the universal mills were two-high but there were several three-high stands equipped with vertical rolls.

The simple two-high mill is of course the elemental type and is historically the oldest. To make successive passes with a single stand of two-high rolls the drive will usually be reversing. Two-high mills, particularly for light gauge plate, soon reach their practical limit of width. If we attempt to increase the roll diameter to provide the necessary strength and stiffness, we also increase the total pressure between the rolls by exposing a greater projected width or arc of contact between the metal and the rolls and so tend to defeat our purpose. The answer lies of course in some form of backed-up mill with relatively small working rolls and larger, stronger and stiffer backing rolls.

The three-high plate mill is to a certain degree a backed-up mill, since the middle roll is generally made smaller than the top and bottom rolls and we gain thereby the advantage of working the metal with one relatively small roll against a larger roll that serves both as a backing roll and as a working roll. Incidentally the rolling load of a three-high plate mill is not taken as a radial load on the middle roll bearings at all, but is carried only on the bearings of the top and bottom rolls. We have also gained an advantage in that we do not need to provide a reversing drive but this is at the expense of the necessity of making tilting tables to serve the mill. This feature of the non-reversing drive, taken by itself, may be quite an advantage with respect to cost and simplicity as an a-c flywheel drive may be used. However there is a recent tendency to install d-c adjustable speed drives to take advantage of a comparatively low entering speed for heavy drafts and a higher speed for finishing passes.

The three-high design of mill for rolling plate is fundamentally good but if we are to take full advantage of the backed-up roll principle it is necessary to go to the four-high mill which is the simplest form of the one hundred per cent backed up mill. The work rolls do not take any of the rolling load on their own bearings but transfer the load directly to the back up rolls and through them to the back up roll bearings. Figure 5 is an installation view showing the delivery side of a typical reversing four-high plate mill. Figure 6 is a close up view of the delivery side of the same mill.

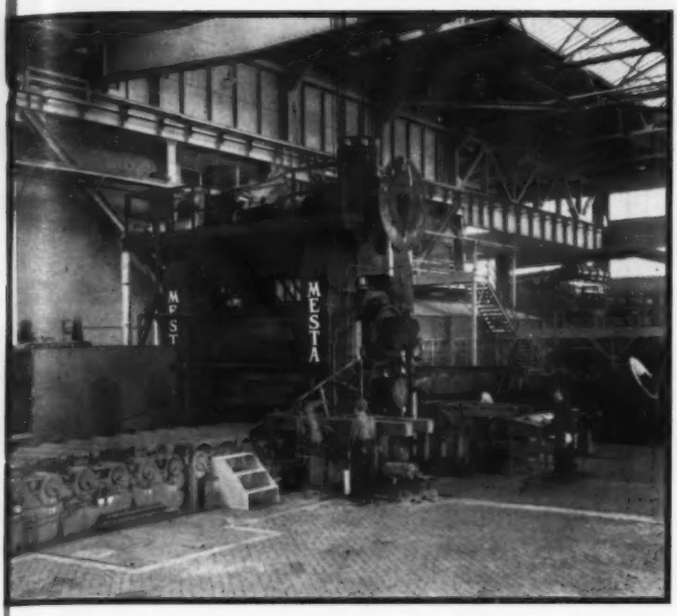


Figure 5 — Delivery side of typical reversing four-high plate mill installation.

When most of the three-high plate mills in this country were built, the four-high mill had not been developed or at least it was not in common use. During the period between the two world wars, when the demand for plates was relatively small and the market for light accurate gauge flat rolled products began to increase by leaps and bounds, the four-high strip mill was developed and came into its own. It was therefore quite natural that, when the war-time tide turned again to plates, the advantages of the four-high mill would make it the preeminent type in the list of new installations.

However as early as 1918 a single stand four-high mill 206 inches wide was installed by the Lukens Steel Company at Coatesville, Pennsylvania, and this mill is still the widest plate mill in the country and perhaps in the world. There were two other notable installations of four-high plate mills prior to the present war. The 96 in. continuous mill of the Carnegie-Illinois Steel Corporation at South Chicago, Illinois, was built primarily as a plate mill but was in reality a part of the strip mill development. In fact it was later rebuilt by the addition of finishing stands and coiling equipment to enable it to roll lighter gauges. In 1936 the Carnegie-Illinois Steel Corporation installed at Homestead, Pennsylvania, a seven stand semi-continuous mill 100 in. wide. This has since been widened to 110 in.

With this background of practice and experience, the country has entered upon the new war-time phase of plate mill development. Four of the nine mills previously enumerated are essentially single stand four-high mills. Three of these are beyond the boundaries of the United States. Four more mills are two-stand installations, two of them having three-high roughers and four-high finishers, another having a two-high rougher and a three-high finisher, and the fourth having two two-high stands. The only continuous mill in the list is the 132 in. mill being installed in the west.

COMPONENT PARTS OF THE PLATE MILL PLANT

The foregoing brief description will serve to classify the new mills according to the type of mill stand or combination of stands employed. It will be well to discuss at this point some of the other component parts or functional elements of the complete plate mill plant and to see how these elements work together to produce the finished plate from the ingot or slab and how they are combined in recent layouts.

Where a primary mill is available for rolling slabs from cast ingots of suitable size and shape, the plate mill is generally served with reheated slabs rolled in the slabbing mill, but frequently the plate mill itself is designed to start with cast ingots and roll them down in one or more stands to the finished plate thickness. Where cast ingots are served to the plate mill, the ingots may come directly from the soaking pits with the ingot heat, or cold ingots may be reheated in soaking pits, in-and-out furnaces or even in continuous furnaces which have been designed primarily for reheating rolled slabs.

Figure 6 — Closeup view of the mill shown in Figure 5.

Where plates are rolled from slabs produced in a primary or slabbing mill the plate mill stand or stands may be in line with the primary mill or adjacent to it for direct rolling without reheating. Or heating furnaces may be interposed in the layout in such a way that the hot slabs from the slabbing mill may be charged into the furnaces as they come from the slabbing mill and given a wash heat so that they are delivered to the plate mill at a controlled rolling temperature. Usually,

however, it is necessary or desirable to stock cold slabs in the slab yard and charge them as needed after suitable flame conditioning, and this would ordinarily be done even where the plate mill is in direct line with the slabbing mill. An exception to this would be where plates are rolled directly from cast ingots in a single stand or two stands in close proximity where no reheating facilities are provided. Of course, when slabs are brought to the plate mill from a remote source, there is no choice but to reheat from cold slabs.

Heating furnaces are an important subject in themselves beyond the scope of this paper except in so far as they affect or are affected by the general mill layout. The furnaces employed fall into three broad classifications: vertically charged soaking pits for cast ingots, continuous furnaces especially adapted for heating or reheating rolled slabs, and side door furnaces of the in-and-out type capable of heating a considerable variety of shapes and sizes of either slabs or ingots.

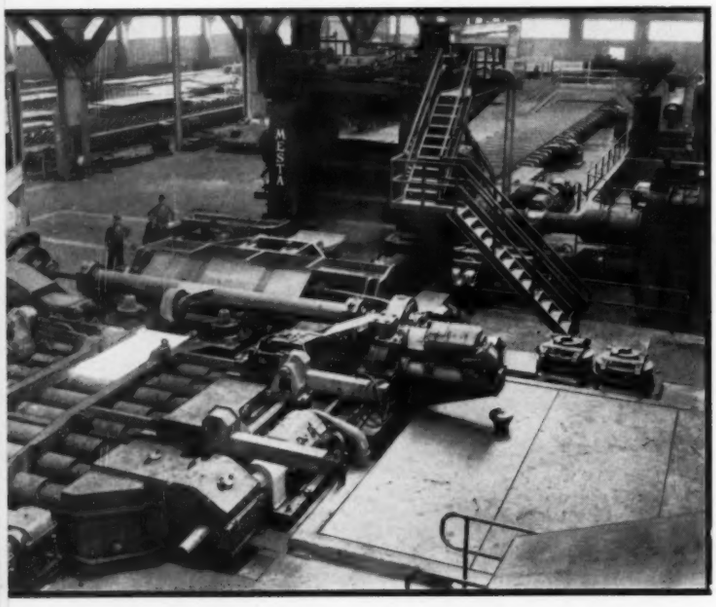


Figure 7 — Independent under-driven edger on the approach side of a reversing four-high mill.

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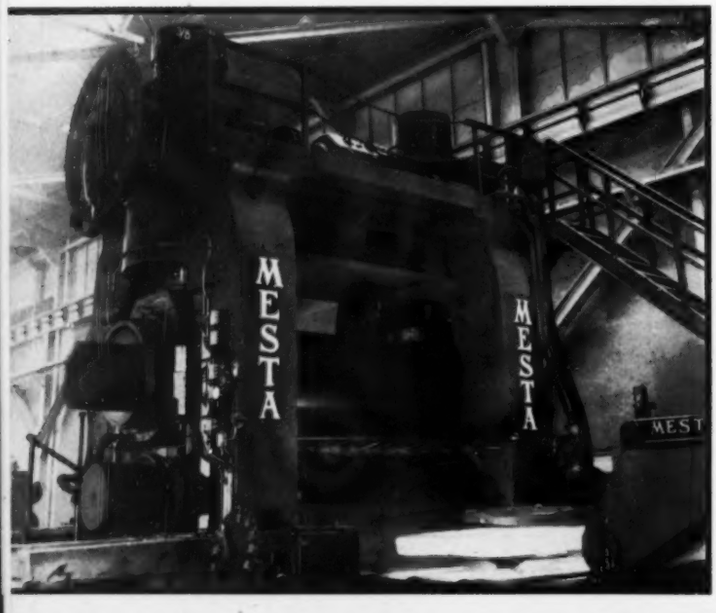
Figure 8 — View showing hydraulic lift slab turner and pusher ram at entry to a reversing four-high plate mill.



Each of these types has its own problems relating to mechanical handling of material and auxiliary equipment. No particular mention need be made of the mechanical equipment for soaking pit charging or for serving ingots to the mills as these features are in common use in considerable variety in connection with all blooming and slabbing mills. In-and-out furnaces are best served with stiff-legged traveling cranes usually equipped with a swivel arrangement for greater ease in covering furnace hearths, mill approach table and adjacent floor area.

Continuous furnaces must have convenient mechanical equipment for feeding and charging, consisting usually of suitable pushers for feeding slabs through the furnace, and charging tables or skid rails from which the slabs are pushed onto the furnace hearth. When a cold slab is pushed onto the hearth at the charging end, all of the slabs on the hearth are advanced approximately the width of one slab and the last slab in the furnace at the hot end is pushed off the level portion of the hearth and slides down inclined chutes to the furnace delivery table where the impact is taken up by spring-backed bumpers. At the charging end, various means are used for bringing the slabs in the desired sequence to the proper charging position in line with the pusher rams. One of the simplest means is to stack the slabs in order within the range of an overhead or half-gantry crane which lifts them one at a time and deposits them on the furnace charging table with magnet or tongs. Where there are two or more furnaces a driven roller table of suitable length extending across the charging ends of the furnaces is a most convenient method of conveying the slabs to the charging position. Elevating or depressing magazine unpilers of different types are frequently used to deliver slabs one at a time from a properly arranged pile to the charging table.

From the discharge end of the furnace the slabs are conveyed by driven roller tables to the mill stands. Scale removal deserves careful consideration for the quality of surface in the finished plate depends to a great extent upon the thoroughness with which the scale is removed. In many modern mills a horizontal scale breaking roll stand, taking a light draft, or an edging stand is used for the purpose of cracking the scale, after which high pressure hydraulic sprays serve to scour the surface and remove the loosened scale. Edging rolls are very effective up to a certain width in breaking scale as well as for controlling the edge of the plate. Figure 7 shows an independent under-driven edger at the approach side of a reversing four-high mill. The hydraulic sprays are located just beyond the edger and between the edger and the mill.

The different types of mill stands used for rolling plate have been mentioned previously and no further discussion of construction details will be attempted at this point. Manipulating side guards are necessary at the mill stands for centering and squaring the slab before entering the initial pass and at times between passes.

In rolling wide plate the widest slab available is sel-

dom of sufficient width to make the plate width, and the slab must therefore be turned 90 degrees and rolled broadside in a spreading stand until the original width dimension of the slab is elongated to a width that will finish to the desired plate width. The slab is then again turned 90 degrees and rolled down to the desired gauge. This cross rolling has other benefits in that the material is worked in two directions. In spreading, the length of the slab that can be rolled is of course limited to the width of the spreading stand while the length of the slabs that require no spreading pass has no such limitation.

Turn-arounds may be either entirely mechanical or they may be of the lifting plunger type with a hydraulic plunger lift and a mechanical turning drive. Figure 8 shows a turn-around of the latter type with pusher ram at the entry side of a reversing four-high plate mill. Another design employs a number of table rollers arranged to taper alternately from opposite ends, alternate rollers being on separate drives. By running the drives in opposite directions the slab may be turned even while advancing it on the table.

Pushers of screw, mechanical linkage or other types are sometimes used to assist in squaring and entering a thick slab into a roughing or spreading stand and this device is also made to return a slab through a non-reversing stand for a second pass in which case we have the equivalent of another single pass stand.

Once rolled to the finished gauge the plate is conveyed on roller tables to the levelers. Hot leveling must be done at the proper temperatures and for light gauge plate the leveler should be located so that the plates will reach it before they are cooled to a temperature where the leveling operation produces "breaks" caused by working the metal in the critical temperature range where brittleness exists. A leveler location that is suitable for leveling light plate will not be ideal for heavy plate as the heavy plate will be too hot for effective leveling. Where possible two levelers should be provided in different locations with the light leveler nearest to the mill.

Aside from the question of leveling, the first problem in the finishing end of a plate mill plant is to provide sufficient cooling area and length in the plate travel so that the plates are cool enough to be marked, handled and sheared without reducing output by holding up the mill. This is of primary importance in a plate mill layout. Main reliance for cooling is usually placed on cooling beds of the cross transfer type providing relatively slow lateral or cross travel of the plates with an effective up draft of air so as to afford adequate cooling time. The area should be sufficient so that the bed will move a certain number of tons per hour corresponding to the mill capacity at an average speed low enough to provide the requisite cooling. The travel of the plates on the tables is also an important factor in bringing the temperature down so that the tables serve both to convey and to cool the product.

Plate mill finishing tables may be of any one of several different designs. They may have cylindrical or disc rollers. Disc rollers with staggered discs are well adapted for supporting and transporting either hot or cold plates. The rollers may be driven by bevel gears from a common line shaft or they may be driven by individual motors. Another common type of conveying table consists of longitudinal chains carrying disc rollers running on tracks. The plates are carried on the top surface of the rollers and move at twice the chain speed.

When cooled to a temperature low enough to permit handling, the plate as rolled from the mill must be cropped by an end shear and much of the average product must be marked for shearing to the finished dimensions called for on the order. Frequently, however the front end cropping is done while the plate is still hot.

Usually this marking is done by hand with hot chalk while the plates are moving slowly forward on the table although one or two mills have marking machines for rectangular marking. The marking table should be arranged so that the men can reach the plate as conveniently as possible and the travel of the plate should be from right to left when standing at the marker's side of the table. The reason for this will be pointed out. Much of the marking consists of order number, heat number, customer's name, dimensions and other written or printed marks of identification and this type of marking can be done very well while the plate is moving slowly forward from right to left, the marking of course reading from left to right. With this arrangement the marker may not have to move very far to follow the moving plate, whereas if the plate traveled from left to right it would be practically impossible to do the necessary marking by hand from the mill floor with the plates moving. Obviously also the table drives should be at the opposite side of the table where they will not interfere with the marking operation. With respect to plates that are to be sheared into a number of pieces the markers have the responsibility of laying out the sizes and shapes to the best advantage on the unsheared plate so as to avoid unnecessary waste.

After they are marked the plates move on to the shearing or flame cutting departments. These operations are of prime importance in the entire scheme of plate mill design and operation. It is evident that considerable hand labor may be involved in handling and shearing a large volume of plates by the usual conventional method and these operations may well prove to be the critical item in the production of finished plate. Therefore any successful substitution of mechanical handling for manual labor or any possible elimination of superfluous operations is likely to pay rich dividends.

The side trimming operation especially on heavy plates is one that is particularly important and one that requires the greatest amount of both of heavy handling and cutting equipment and of hand labor. The production of universal plate in 1942 was only 12 per cent of the total. The other 88 per cent came from the sheared plate mills and the continuous strip mills, hence the importance of the side trimming operation for sheared plate mills. However with the increased demand for plate there came also revolutionary changes in fabrication methods particularly in the ship yards. Riveted construction gave way to welding almost universally and most ship plates were cut to template at the yards. In addition it was discovered that for welding purposes the edge produced by mills employing edging passes was better than a sheared edge. These changes permitted the acceptance of an increasing percentage of mill edge plates particularly from the continuous mills

which can produce a very good mill or band edge. This change in practice has to a very great extent relieved the load on the shearing capacity of the sheared plate mills.

We have mentioned that the first shearing operation on the plate after rolling is to crop the irregular front end. This is usually done by a conventional down-cut guillotine shear of suitable width with a raked upper knife. The cutting to length and rear end cropping is also done with similar shears. This introduces the problem of "shear bow" when cutting with a raked knife. The portion of the plate that is sheared away by the knife which carries the rake tends to curl away from the cut, and this produces a "bow" of greater or less extent depending on the amount of rake, the thickness of the plate, the width or length sheared off, the condition of the knives, the character of the steel and other factors. It seems to be impossible to eliminate or avoid this altogether and of course it is of no importance as far as the finished plate is concerned if the "bow" is taken only on the scrap material trimmed from the ends or sides of the plate.

In making successive end cuts to length or in dividing a plate, the bow must be taken on one or the other of the pieces but the lengths cut are usually so great that the stiffness of the plate reduces the amount of the bow to a minimum. In cropping the front end however the shear should be placed so that the irregular leading end is sheared off by the leading knife which carries the rake (that is the top knife) in the case of a down-cut shear) so that the scrap will have the "bow" and the good plate will not. In cropping the rear end to salvage the random length of plate which may be left in excess of the ordered length or lengths, the conditions are reversed and the rear crop should be sheared off by the knife which carries the rake. This makes it impossible to crop both ends of a plate with the same shear without turning the plate if the shear "bow" is to be taken by the scrap only. If possible, therefore, as it is usually impractical to turn the plate, a second shear should be used for cutting to length and rear end cropping and this shear should be arranged so that the knife which crops the rear end will have the rake, and not the leading knife as for front end cropping.

As previously mentioned, side trimming and slitting behind a high production mill might easily limit the mill output. The rotary type of side trimming and slitting shear offers a very attractive solution of this difficulty. Shears of this type have offset rotary circular disc knives mounted on arbors or overhung shafts. Both knives are driven and arrangements can be made to guide and advance the plate continuously through the shear at a fairly high speed with a minimum of manual attention. The use of rotary trimming shears in a high production mill is of great importance since the plates may proceed through the shears without starting and stopping as is necessary with guillotine shears. A valuable feature of the rotary trimming shear is the comparative ease with which scrap cutters can be built into the unit to cut the side trim into lengths that can be easily removed by chute or conveyor. To complete the shearing unit an end shear with a convenient mechanical gauge should be installed behind the rotary shear to cut the trimmed plate to lengths as ordered.

The conventional type guillotine shear with raked knife remains the main reliance for both end shearing and side trimming of heavy plate. Most mill layouts have a combined shear group consisting of one end shear for cutting to lengths and two side shears one for trimming each side of the plate. The end shear is usually served by a roller table at the approach side followed by a short depressing table which delivers the plates to a caster bed between the two side shears. The side shears are staggered or offset in relation to each other so that one side of the plate may be trimmed without interference before the plate is advanced to the next shear. The caster bed is arranged for a minimum amount of movement or manual handling of the plates between successive cuts. The side shear housings are usually of the gap or "C" type which permits slitting a long plate on occasion although it is quite difficult to handle a heavy plate through a side shear manually while slitting and it is not easy to provide conveying equipment to serve equally well for slitting and side trimming.

The manual handling of heavy plates over a large caster bed area for feeding side trimming guillotine shears naturally leaves much to be desired and mechanized shearing lines usually consisting of two side shears and one end shear have been designed to minimize the manual handling. Roller tables are used for longitudinal movement of the plate and cross travel is effected by suitably spaced electromagnets moved by transverse screws under the table. The magnets are arranged so that the plate is lifted clear of the table rollers for the transverse movement. One or two outfits of this kind will be described in more detail in connection with a description of recent individual installations.

Since a very large percentage of sheared plates are ordered to rectangular shapes, mechanical gauging for length is of great importance in reducing to a minimum marking and handling. The mechanized lines previously referred to have mechanical gauges for cutting to length as have the end shears which follow the rotary trimming shears. One of the side shears in the mechanized line may also be provided with a mechanical gauge to avoid the marking and cutting to line that would otherwise be necessary after one edge has been cut to a marked line on the first side shear.

Besides rectangular plates, those that are cut to shapes other than rectangular are known as sketch plates and provision must be made for shearing them also. They are usually marked from a pattern or template and sheared to line, the plate being manipulated by hand on the caster bed or mechanically where mechanized equipment is available at the shears. Special shapes such as circular plates for dished or flat tank heads, elliptical plates or other irregularly shaped plates up to about $\frac{3}{4}$ in. thickness with curved boundary lines may be cut on the so-called circle shear. This is a special shear with rotary knives having beveled edges and rotating on axes set at a suitable angle with the plate. Circular plates are cut from stock which is clamped or centered on a pivot which may be adjusted relative to the cutting point for any radius within the limits of the equipment. Other shapes are cut to a line, the plate being guided by hand.

One of the troublesome problems in connection with

the shearing of plates is the cutting and disposal of scrap cut from the side trimming and end cutting shears. Rotary side trimmers as previously mentioned are usually provided with their own auxiliary scrap cutting knives which cut the scrap into short pieces that are easily disposed of. End shears and side trimming shears frequently are provided with conveyors for carrying the scrap beyond the shear to a point where it can be reached for handling. Various types of vertical, guillotine, lever or alligator shears or even semi-flying shears have been used for this purpose. Usually the scrap is collected in buckets in scrap pits or is bundled at the shears for removal from the shear building. The handling of heavy scrap from wide side shears is particularly troublesome.

Flame cutting with oxy-acetylene torches is playing an increasingly important part in the work of cutting plates at the mills into the desired marketable sizes and shapes. This method of cutting plate not only has been developed simultaneously with the development of welding as a method of fabrication but has been stimulated by it, for a flame cut edge welds better than a sheared edge and the flame cutting process has fewer limitations. The flame cutting torch can easily cut along irregular or curved lines and has no hard and fast limitations with respect to plate thickness. The latter consideration becomes a particularly important factor when dealing with plate heavier than about 1½ in. in thickness. Any particular shear has a fairly definite limit of capacity with respect to thickness of plate sheared. Furthermore the total pressure or force required to push a shear knife of a given rake through the cut increases very rapidly with the plate thickness. This shearing force varies as a power of the plate thickness, ranging from 1.6 exponent up to about the square of the thickness.

As long as riveted construction was the predominant method of fabrication the smooth and square shear cut edge was desirable and necessary. Welded construction on the contrary requires no special smoothness of edge since the original edge is covered by the welding material anyway but various forms of bevels or so-called edge preparation are required that are easily accomplished by flame cutting but are entirely beyond the ability of any shearing equipment.

Another advantage of the flame cutting process lies in the fact that no very heavy mechanical equipment is required though mechanical aids of various kinds are necessary to fully develop its possibilities. The simplest form of cutting equipment is the hand torch but hand torches are not suitable for production work because the edges produced are irregular and the work is necessarily laborious. Some mechanical means of guiding and feeding the torch is desirable. Of all the mechanical equipment thus far developed the portable cutting torch with motor driven wheels or rollers is the simplest. This device can be carried from plate to plate as the torch is made to travel directly on the work. Tracks are provided for guiding the torch for straight line travel. Circles can be cut with the aid of a suitable radius rod and irregular shapes can be cut to a previously marked out pattern by hand guiding of the feeding wheel. Bevel cuts can also be made with a suitable attachment.

More elaborate equipment is available for pattern cutting in the pantograph or similar outfits with two carriages operating at right angles. The principal features of these machines is that the tracing point is located at some distance from the cutting torch or torches. The patterns or templates are laid out on convenient tracing tables and the plate is supported on adjacent work tables.

The pantograph outfits are furnished as stationary equipment with tracing points or wheels covering a limited area, or the entire machine can be built to travel on a rectilinear track to cover an area having its width limited by the pantograph motion, but of a length limited only by the length of track which is provided. These machines are adapted for cutting all kinds of shapes such as locomotive frames, machine frames, gear blanks and rims and the various other shapes and sizes that are used in modern welded construction.

Multiple cutting is accomplished for light and moderate plate thicknesses by stacking the plates to an overall thickness within the economical thickness range of the cutting torch and cutting several thicknesses at once to make duplicate shapes. As an alternate to this method especially for heavier plates, multiple torches are secured to one cutting arm and as the tracing wheel is guided around the pattern, or template, several duplicate shapes are cut with one tracing. If the number of pieces to be cut warrants the expense, cam-like templates can be made which serve to guide the tracing point automatically with a minimum of attention from the operator.

Compared with the volume of plates now going into ships, armored tanks and other implements and paraphernalia of war, the tonnage that is being applied or is likely to be applied to such purposes as require these small duplicate shapes may seem to be relatively small and insignificant, but we are perhaps approaching a time when small peace time orders will not be despised, after "the tumult and the shouting dies and the captains and the kings depart."

If the class of flame-cut products which we have just been discussing seems somewhat of a specialty to the average plate mill man we may now mention a type of flame cutting machine that is designed to trim, slit, end-cut and edge condition a considerable tonnage of medium weight and heavy plate on a real production basis. This outfit consists of a trimming and slitting carriage traveling on rails and carrying several torches arranged for side trimming, slitting and beveling or edge conditioning. Two other carriages with cross travel torches are located one at each end of the trimming carriage and run on the same rails. The end cutting carriages are run to a position on the rails which measures between them the desired length of plate, the torches on each serving to make the front and rear end cuts. The longitudinal and cross travel carriages cover the working area where the burning is done. This area is usually served by a disc roller table occupying the space between the rails. This table is extended to the front and rear so that plates may be loaded by crane onto the table at the receiving end, travel through the working area under the torch carriages and emerge on a delivery table cut, trimmed or slit to size and with edges beveled as desired. The finished plate is then lifted from the table by crane and lifting magnet. Special provisions

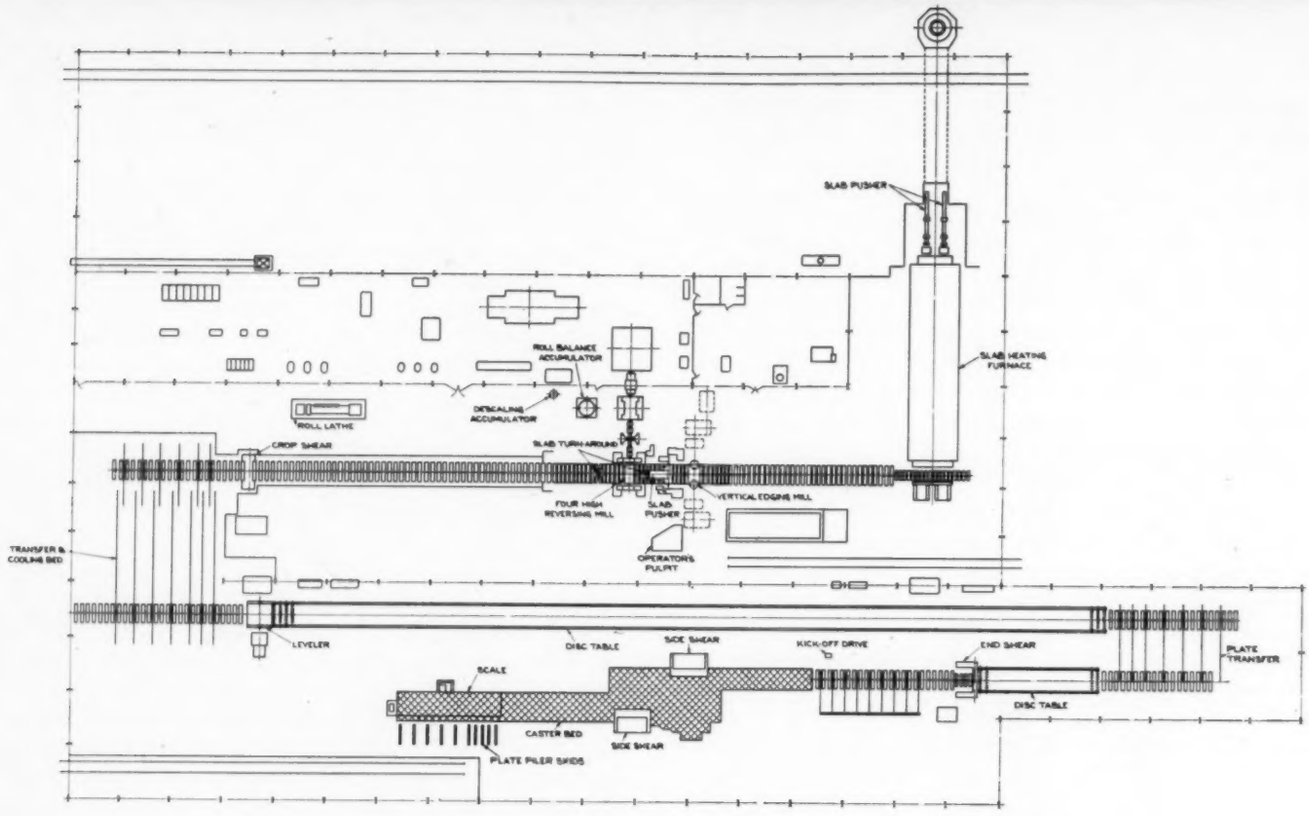


Figure 9 — Layout of single stand 110 in. four-high reversing plate mill at Steel Company of Canada, Ltd., Hamilton, Ontario.

are made at the entry end of the equipment for convenient alignment of the untrimmed plate to the torch and carriage travel. An outfit of this kind will be described in more detail in connection with one of the recent plate mill projects.

The inspection of plates may perhaps be best described as a process and not an act, as it must begin with the chemical analysis of the heat of steel which goes into the ingot or slab from which the plate is rolled. Throughout the rolling process the plate must be watched carefully for width, gauge, camber, etc. and sheared plates must be checked for size. Finally the plate must be examined for surface defects such as seams, cracks, blisters, laminations, etc. and rejected plates must be reclaimed where possible by cutting them down to smaller sizes for other orders in such a way that the defects are eliminated. If possible, provision should be made in the layout for getting these reclaimed plates back into the shearing lines after they have been marked for reshearing.

Where plates are to be inspected on both sides for surface defects, some provision must be made for examining the under side. The simplest way of doing this where turnovers are not available is to provide horses of a convenient height on which the plates may be laid so as to make the under side accessible for visual inspection.

Provision must also be made for shearing test specimens from which standard test pieces for physical tests may be cut. Specifications may require that these be taken in such a way that the test pieces as cut from the plate be at right angles to the direction of rolling or parallel to it or both. Sometimes a small test shear is provided in or near the physical laboratory for cutting the roughed out specimens down to the overall rectangular size of the standard test piece which is usually finished to shape in a shaper.

It is usually necessary to weigh each finished plate separately and this necessitates scales mounted under a section of runout table or under a portion of the caster bed beyond the shears. After being weighed the finished plates are rolled or pushed off the table by suitable roll-offs or push-offs onto piling cradles or are lifted off the caster bed and piled for shipment. Considerable space is required in the shipping building or shipping area for piling or stacking orders that are being prepared and marked for shipment. A congested shipping floor where the available space is not sufficient can cause a great deal of delay and inconvenience in the prompt handling of outgoing shipments.

Having thus discussed briefly the salient features and functions of the items of equipment that go to make up the complete plate mill plant, we turn now to a more detailed description of several of the recent installations.

STEEL COMPANY OF CANADA, HAMILTON, ONTARIO

Of those mills enumerated in the introductory paragraphs of this paper, that of the Steel Company of Canada at Hamilton, Ontario, was the first to go into operation having been started early in 1941. This mill

was described by T. J. Ess in the April, 1942, issue of the Iron and Steel Engineer. Only a brief description will be given here. It was designed to produce finished plates down to 3/16 in. thick in widths from 20 in. to 98 in. from reheated slabs 20 in. to 45 in. wide by 4 in. to 12 in. thick. The heaviest slab weighs about 16,000 lb.A portion of the product is rolled from bottom cast ingots, 12 in. thick and up to 42 in. wide.

Figure 9 shows the layout of the mill. The slabs or ingots are reheated in a continuous furnace having a hearth 20 ft wide x 80 ft long. They are charged from the adjacent yard and pushed through the furnace by two motor driven rack type pushers. At the discharge end of the furnace they slide down delivery chutes to the furnace delivery table and from there are conveyed to the mill.

The rolling equipment consists of a 38 in. and 52 in. x 110 in. four-high reversing mill preceded by an underdriven vertical edger. The four-high mill is driven directly through a universal leading spindle, mill pinions 40 in. in diameter x 66 in. face and universal mill spindles by a 5000 hp, 700 volt reversing motor running 35 to 80 rpm. With work rolls 38 in. diameter the roll surface speed is approximately 350 to 800 fpm.

The back up rolls are 52 in. in diameter x 108 in. length of body and are supported on oil film bearings and anchored to the mill housings by self-aligning roller thrust bearings. The work rolls are 38 in. in diameter x 110 in. length of body and are provided with four-row tapered bearings mounted in bearing boxes that are housed within the back-up roll bearing boxes. The end thrust of the work rolls however is carried directly to the mill housings and there is no end thrust from any source whatever on the back up roll boxes. A general view of the mill from the delivery side is shown in Figure 10. This view shows the mill runout table with the mill in the background.

The weight of the top roll assembly is balanced by hydraulic pressure on plungers mounted in the bottom back-up roll bearing boxes. The roll balance system is a self-contained hydraulic system with a vertical triplex reciprocating pump and a weight-loaded accumulator.

The work rolls are changed with a counterweighted peel and the entire back-up roll assembly is moved into and out of the mill on a motor driven slide.

The housing screws are 18 in. in diameter with threads of 1 in. pitch geared for a screw speed of 30 in. per minute. Each screw is driven by a 75 hp mill type motor, the motors being connected together mechanically through a magnetic clutch by means of which the rolls are leveled or trimmed.

The work rolls open to a maximum gap of 10 in. to 12 in. depending on the roll diameter. A mechanical dial indicator easily visible from the pulpit shows the position of the rolls at all times. Figure 11 shows a view of the mill from the delivery side with a plate just emerging. The approach tables and continuous heating furnaces are visible in the background.

The vertical edger has overhung flanged rolls of 40 in. diameter. These are keyed to tapered vertical spindle extensions to facilitate roll changes. The spindles run in cylindrical roller type roller bearings with roller thrust bearings. The edger is driven by a 500 hp, 700 volt motor, 125 to 406 rpm, through gear drives under floor level on each side of the edger. These drives are interconnected mechanically through a transverse drive or equalizer shaft.

The main drive motor generator set is a flywheel set consisting of a 5000 hp, 490 rpm, 13,200 volt, 3 phase, 25 cycle, a-c, wound rotor induction motor and two 2500 kw, 490 rpm, 700 volt, d-c generators.

The four-high mill is served by reversing tables powered by four 100 hp mill type motors. Slabs are turned on these tables for spreading by two turn tables with hydraulic lift and mechanical turning through a motor driven crank motion working in a horizontal plane. A mechanical link type pusher is provided to assist in squaring the slab for entry to the mill especially on the broadside passes.

The mill is provided with a high pressure hydraulic descaling system consisting of a multistage centrifugal

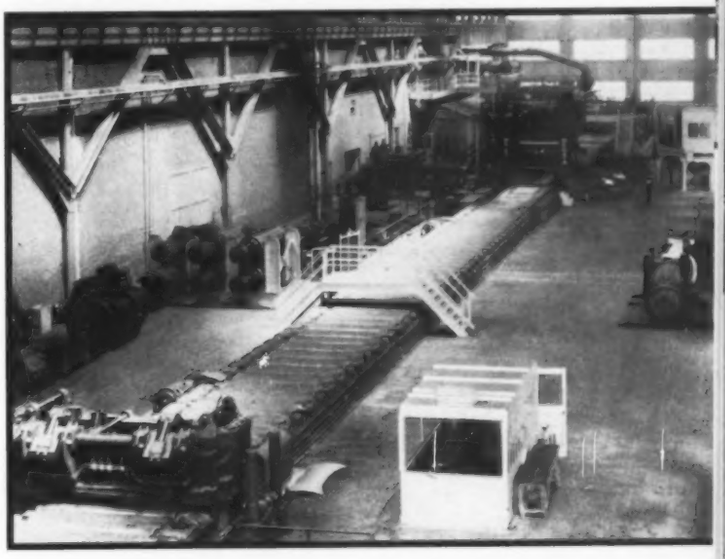
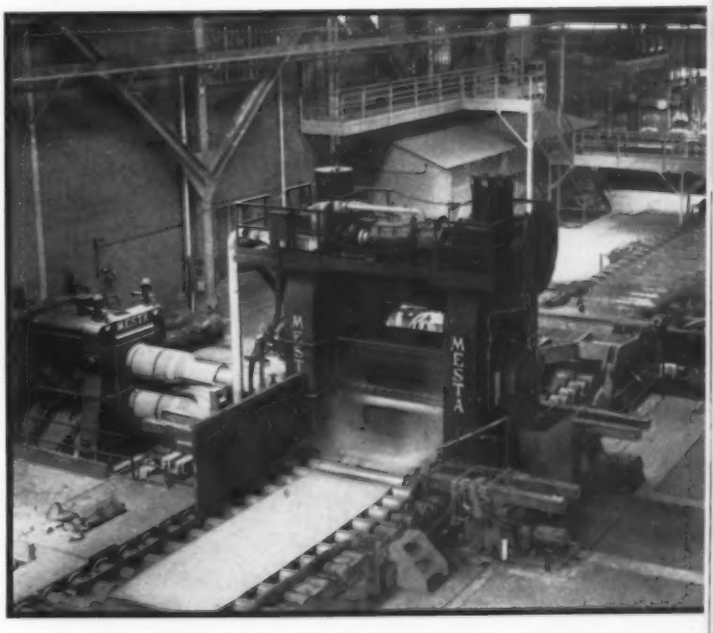


Figure 10 — General view of the Steel Company of Canada, Ltd., 110 in. mill from the delivery side.

Figure 11 — Closeup of 110 in. mill from delivery side.



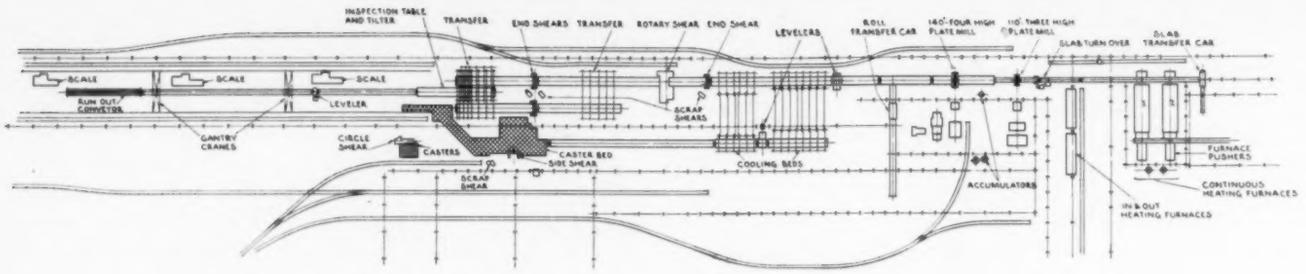


Figure 12 — Layout of 140 in. plate mill at Tennessee Coal, Iron and Railroad Company, Fairfield, Alabama.

pump and a hydro-pneumatic accumulator. Removal of furnace scale by hydraulic sprays after the edger is particularly effective, as the edging operation thoroughly breaks up the scale with no tendency to roll it in.

From the mill the plates run out to a chain-type cooling bed through a crop and dividing shear and move across the bed to a parallel marking table leading in a direction opposite to the runout from the mill. A leveler is located at the entry end of this table.

Originally the finishing end of the mill was designed for a relatively small plate tonnage but war conditions increased the demand for plates to a point where additional finishing equipment was required immediately. The finishing end of the mill now consists of a typical kick off and caster bed outlet, doubling back from a second transfer, to the shear and caster bed area.

Shearing equipment consists of an end shear with tables and two side shears served by the caster bed. A portion of the caster area runs over a scale platform where individual plates are weighed before being pushed off for loading.

TENNESSEE COAL, IRON AND RAILROAD COMPANY

The next of the new mills to go into production was the 140 in. mill of the Tennessee Coal, Iron and Railroad Company at Fairfield Works, Birmingham, Alabama. This mill was started in May, 1942. It was not a completely new installation but consisted of one new 140 in. wide four-high finishing stand located behind an existing 110 in. wide three-high mill that had been in service since 1918. Extensive changes and additions were also made to the heating and finishing equipment. An unusual feature in connection with this installation is the fact that the old mill was kept in production practically all the time during the erection of the new equipment, and in fact, broke all previous tonnage records during this period. An interesting paper on this mill describing the old and the new layouts and the erection problems encountered was presented on March 29, 1943 before the Birmingham District Section of the Association of Iron and Steel Engineers by J. D. Clark, chief draftsman of the Tennessee Coal, Iron and Railroad Company, Ensley, Alabama. This paper was published in the October, 1943, issue of the Iron and Steel Engineer.

Since this publication is of such recent date no attempt will be made here to describe the installation fully but we wish to present along with the layouts of some of the other new mills an outline drawing, Figure 12, of the Tennessee mill in order to point to the outstanding features of the new layout.

The mill is designed to produce finished plates up to 128 in. wide by 60 ft long in a thickness range between $\frac{3}{16}$ in. and $1\frac{1}{4}$ in. It will be apparent that the addition of a heavy four-high stand 140 in. wide, using the existing 110 in. mill as a rougher, makes it possible not only to finish a wider plate and to maintain a greater uniformity of gauge across the width of wide plates but also to produce a much greater tonnage from the combination mill.

For rolling plates wider than about 100 in., some spreading must be done in the finishing mill as well as in the roughing mill as the width of plate that can be finished by straight-away rolling is limited by the slab or breakdown that can be passed through the 110 in. rougher.

The slabs themselves are rolled on nearby slabbing or blooming mills and are delivered by slab cars to the slab yard adjacent to the heating furnaces. The furnace equipment now consists of two new continuous heating furnaces with hearth dimensions of 20 ft x 60 ft, fired principally from the charging end, and two in-and-out furnaces retained from the original 110 in. mill layout. Slabs range in thickness from 4 in. to 15 in., with a maximum width of 54 in. Slabs are charged into the continuous furnaces in two rows, each row fed by a motor driven rack type pusher. The largest slabs charged are 105 in. long and weigh up to 18,000 lb.

The slabs are ordinarily roughed down in the 110 in. mill to a thickness and length that will permit them to be finished in the 140 in. mill in approximately five passes with an average total reduction of about 50 per cent in thickness. The 110 in. mill is driven by a 4000 hp, 82 rpm, 3 phase, 60 cycle, 6600 volt slip ring induction motor with flywheel between the motor and the mill. The mill is equipped with the usual tilting tables.

The 140 in. mill has back-up rolls of 56 in. diameter x 138 in. length of body, and work rolls of 38 in. diameter x 140 in. length of body. The back-up rolls are supported in oil film bearings and the thrust is taken through outboard roller thrust bearings to the rear mill housing. The work rolls are equipped with four-row tapered roller bearings. The work roll thrust is also taken directly to the mill housing without going through the back up roll bearing boxes. A view of the mill from the delivery side is shown in Figure 13.

The roll balance system consists of a vertical triplex reciprocating pump and weight loaded accumulator. Roll balance plungers are located in the bottom back-up roll bearing boxes.

Back-up roll assemblies are pulled out of the mill for roll changing on a motor driven slide and are then handled one at a time across the rear mill table to a roll transfer car which transports them to the adjacent roll shop. Limitations in width and height of the existing building and the proximity of the working floor of a continuous strip mill in the adjoining building necessitated the design of a special roll changing "C-hook" for changing the work rolls. This rig is equipped with a motor driven, screw-operated slide for shifting the point of suspension from the center of gravity of the empty hook to the center of gravity of the loaded hook when the work rolls are removed from the mill, the shift being made in the reverse direction when the rig is removed from the roll.

The 140 in. mill is powered by a 7000 hp, 35-70 rpm, 700 volt reversing motor having a maximum torque of 2,362,000 lb-ft at the full field speed of the motor. Power is supplied at variable voltage by a motor generator set consisting of two 3000 kw, 352 rpm, d-c generators driven by one 6000 hp, 352 rpm, 6600 volt, 3 phase, 60 cycle wound rotor induction motor with steel plate flywheel storing 175,000 hp-sec total energy at 360 rpm.

The mill screwdown and reversing tables are operated on a variable voltage system from power supplied by a separate motor generator set consisting of one 900 hp, 1200 rpm, 6600 volt, three phase, 60 cycle, a-c induction motor and four 150 kw d-c generators. Each pair of motors for screwdown and front and rear mill tables has its own generator. The generators are of the shovel type with differential compound wound fields, producing high voltage and high speed in the motors at light loads and developing a maximum torque limited to the safe current capacity of the motors even in the stalled motor condition.

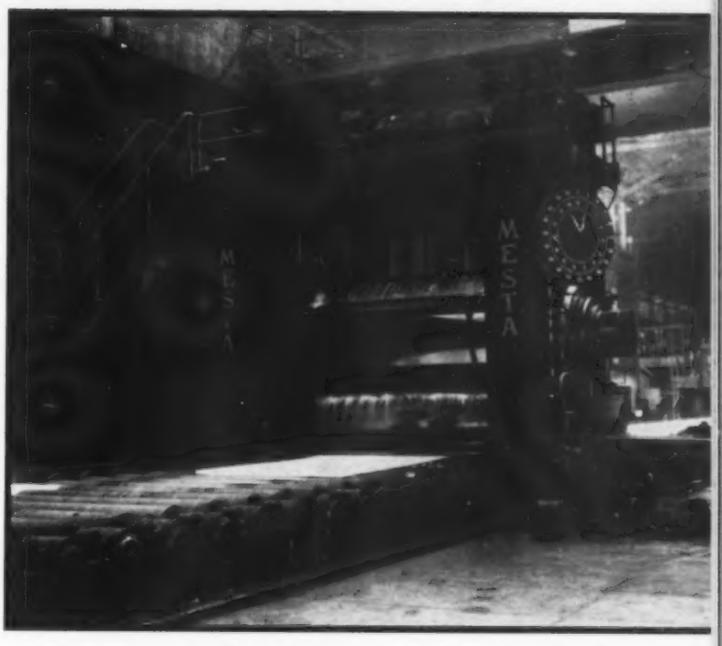


Figure 13 — View of delivery side of 140 in. plate mill at Tennessee Coal, Iron and Railroad Company.

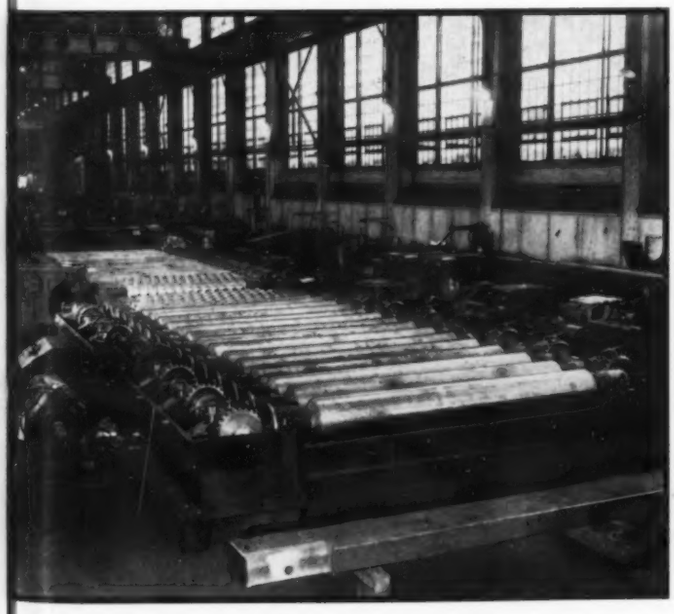
Finish rolling on the 140 in. mill of plates over about 100 in. width necessitates turning the breakdowns 90 degrees, as they are limited to about 100 in. by the width of the roughing unit. Turning is accomplished on the rear mill table by a series of tapered rollers. Alternate rollers are on separate drives and taper slightly in opposite directions. By running the drives in opposite directions the breakdowns are turned, even while advancing on the table. Figure 14 shows a shop view of the front and rear mill tables.

The hydraulic descaling system on this mill consists of two motor driven horizontal duplex reciprocating pumps and hydro-pneumatic accumulator. The pumps are provided with automatic by-pass or unloading valves actuated by solenoid air pilot valves and electric pressure switches which serve to by pass the pumps when the rising water level in the accumulator compresses the air above it to a predetermined pressure.

The principal features of the finishing end of the new mill as extended and re-arranged are shown on the general plan. The straight-away run of roller table from the finishing mill conveys the plate to a roller leveler capable of leveling hot plates up to ¾ in. in thickness. Heavier plates pass through this leveler with the rolls opened up and are transferred over a chain and skid type cooling bed to a side table containing another leveler with a capacity for leveling hot plates from ¾ in. to 1¼ in. in thickness. Plates over 1 in. in thickness and over 120 in. wide continue in the same line with the side table over a chain conveyor to a caster bed serving a single 190 in. sideshear or to a flame cutting area.

Lighter and narrower plates return over another cooling bed transfer to the run off tables in line with the mill. This run is furnished with a crop shear and a rotary side trimming shear.

Figure 14 — Shop view of front and rear mill tables used on 140 in. mill.



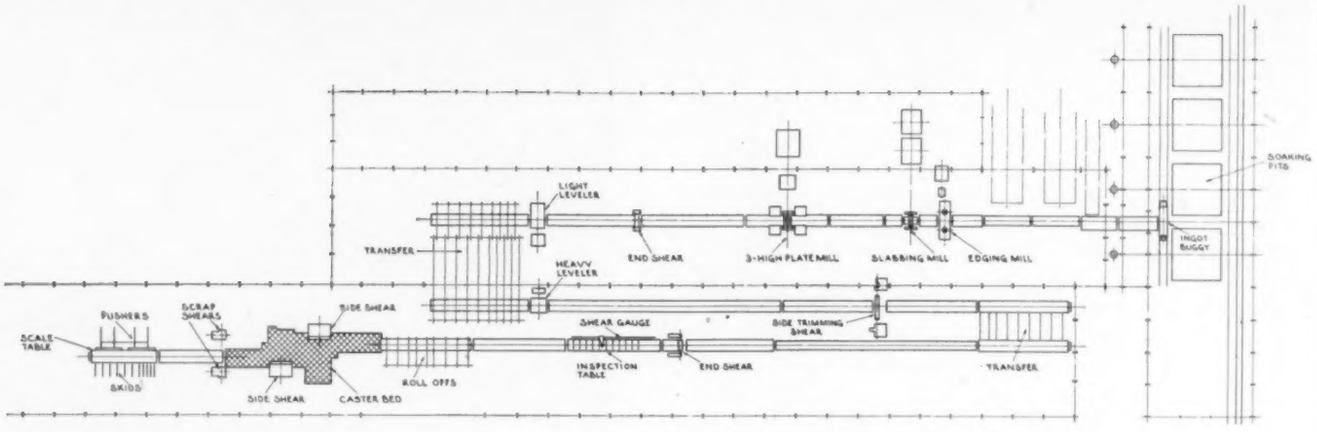


Figure 15 — General plan of 110 in. two-stand plate mill of Kaiser Company, Inc., Fontana, California

After being trimmed the plates continue to the end shears where they are cut to length. Two end shears are available, one in the straight run of table and a second in a short parallel run served by a transfer. Behind the end shears the finished plates from both lines are returned again to a common table by other transfers and pass over an inspection table equipped with a tilter to permit inspection of the under side of the plates.

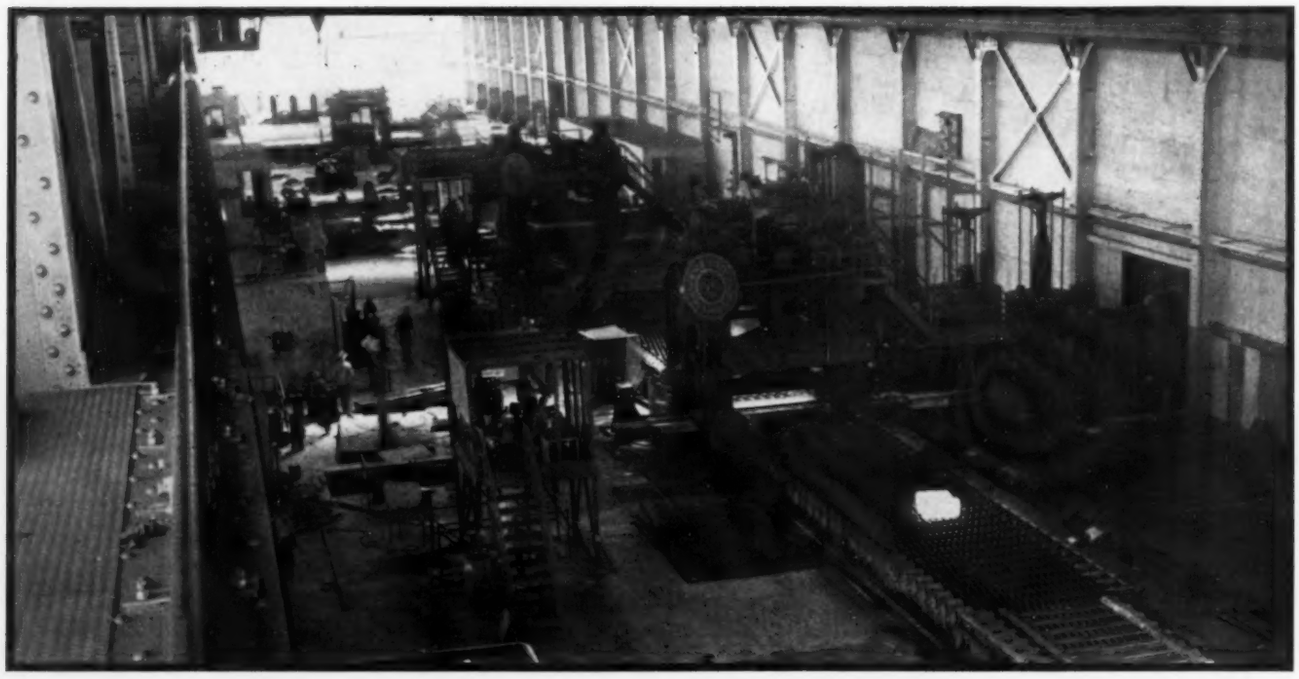
After inspection, the plates are conveyed by roller table to the shipping area where two 7½ ton gantry cranes span this central table and the adjacent stacking area. Shipping tracks on either side of the building outside the span of the gantry piling cranes are served from the piles by overhead traveling cranes.

KAISER COMPANY, INC., FONTANA, CALIFORNIA

The general plan of the 110 in. plate mill of Kaiser Company, Inc., Fontana, California, is shown in Figure 15. This mill is designed to roll plates direct from slab ingots. At present no heating furnaces are installed but provision is made in the layout for a future installation of continuous slab heating furnaces and there is space provided ahead of an adjoining structural mill for a future blooming and slabbing mill which would deliver slabs to a slab yard adjacent to the charging end of the heating furnaces.

In the present layout slab ingots from the soaking pits are delivered to the end of the plate mill approach table by a motor driven side dump ingot buggy which

Figure 16 — General view of the Kaiser mill from the entry end.



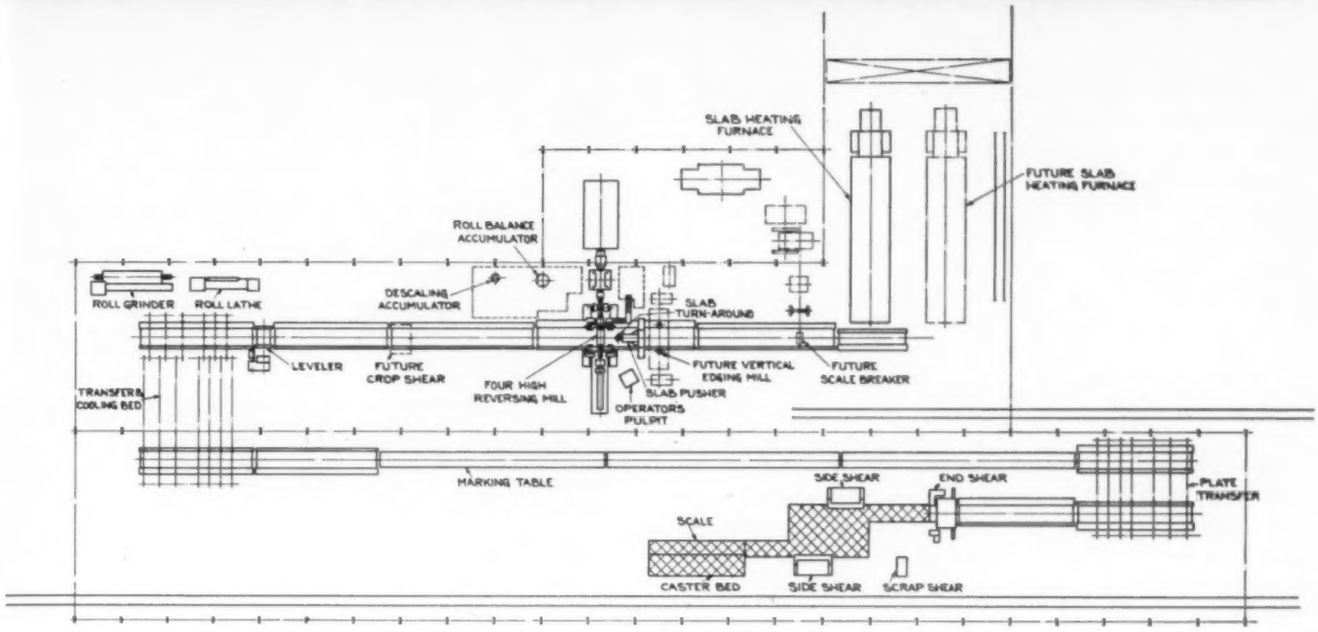


Figure 17 — Plan of 110 in. single stand four-high reversing plate mill at South African Iron and Steel Corporation, Pretoria, South Africa.

runs the length of the soaking pit building and serves the structural mill as well as the plate mill.

The ingots are received on the mill approach table from the side dump buggy and pass through an under-driven vertical edging mill to the two-high roughing stand. This mill has rolls of 44 in. diameter with 110 in. length of body. Top roll and spindle are balanced by hydraulic cylinders. The mill is driven by two 3500 hp reversing motors, one motor driving each roll through a universal spindle without mill pinions. Turnarounds are provided in the reversing tables on each side of the mill to turn ingots and slabs for spreading or broadside passes.

The three-high finishing stand is located 100 ft from the two-high rougher. Top and bottom rolls are 44 in. in diameter x 112 in. overall length of body and the middle roll is 26½ in. x 113 in. overall length of body. Top roll and spindle and middle roll are balanced by hydraulic pressure. Mill pinions are 47¼ in. and 31½ in. pitch diameter x 72 in. face. The mill is driven by a 7000 hp, 750 volt motor running 40 to 120 rpm. Reversing tilting tables with collared rollers serve the mill.

The runout table from the three-high mill conveys the plate through an end shear, which serves as a cropping and dividing shear, to the light plate leveler which is located at the entry end of a chain type cooling bed transfer. The plate is transferred over this bed into the shearing and finishing building where the tables double back in the direction of the mills. The heavy plate leveler is located at the exit end of the bed.

A disc type table is used to convey the plate to an approach table serving a rotary type side trimming shear located about 300 ft beyond the hot bed. Behind the side trimming shear, the plate is again transferred at the end of the building and doubles back again over a lay off or marking table which is also of the disc type. Beyond this table there is an end shear with approach table and roll-off skids. The shear is equipped with a gauge over the runout table for cutting to finished lengths. This table also serves as an inspection table and is equipped with a motor driven turn-up for underside inspection. After inspection the plates cross a scale table where they are weighed and finished plates are rolled off from a section of table beyond the scale table.

Plates that are too heavy to trim on the rotary side trimming shear continue over a caster bed to a shearing floor provided with two side shears and auxiliary scrap cutting equipment. Plates that are finished sheared in this area continue over another table to a scale table equipped with push-offs and skids.

A flame cutting unit for side trimming, slitting and end cutting is located in the same building about opposite the scale.

An area of approximately 100 ft x 300 ft at the end of this building is reserved for plate storage and shipping. It is served by a depressed railroad track and a truck loading ramp and loading area for truck shipments.

This mill was described in detail by W. A. White, superintendent of rolling, Kaiser Company, Inc., in the Iron and Steel Engineer for January, 1944.

SOUTH AFRICAN IRON AND STEEL INDUSTRIAL CORPORATION, LTD.

The 110 in. wide mill of the South African Iron and Steel Corporation, Ltd., Pretoria, Union of South Africa, went into operation November, 1943. The rolling unit consists of a single reversing four-high stand. Roll sizes are 52 in. x 108 in. for the back-up rolls and 38 in. x 110 in. for the working rolls. The back-up rolls run in oil film bearings with outboard roller thrust bearings, and the working rolls are mounted in four-row tapered type roller bearings. The mill housings weigh 230,000

lb each. The bare back-up rolls weigh 92,000 lb each and the total weight of the top and bottom back-up roll assembly with bearings and bearing boxes is 285,000 lb. The screwdown is motored by two 75 hp mill type motors, each driving one screw through worm and worm wheel reductions and connected through a magnetic clutch for leveling and trimming the rolls. The screw speed is 30 in. per minute. The top rolls are balanced by hydraulic pressure through cylinders mounted in the bottom back-up roll bearing boxes. A vertical triplex reciprocating plunger pump with weight loaded accumulator constitutes the rest of the roll balance system. The mill is powered by a 5400 hp, 40 to 80 rpm, d-c reversing motor which drives the rolls through a large flexible leading coupling, pinion stand and universal mill spindles. The mill pinions are 40 in. in diameter x 66 in. face. The roll surface speeds at the motor speeds mentioned above are 400 to 800 fpm.

Figure 17 shows the general plan of the mill. In laying out this mill every essential of a complete sheared plate mill was included and, besides, provision was made in the layout for the addition in the future of certain auxiliaries which will be mentioned.

The present installation has a single continuous slab heating furnace with space left in the furnace building for a second furnace. The furnace is equipped with a magazine type motor driven double furnace pusher arranged with two racks for pushing two rows of slabs through the furnace. Slabs are handled by means of an overhead traveling crane from the adjacent slab yard which is an extension of the furnace building.

Provision is made for the future installation of a self contained underdriven vertical edger in front of the four-high stand and a horizontal scale breaking stand close to the furnace delivery table.

A hydraulic descaling system is provided consisting of a horizontal duplex reciprocating pump and a hydropneumatic accumulator.

A section of furnace delivery table equipped with spring bumpers receives the slab as it is discharged from the furnace and delivers it to the mill approach table. The table equipment at the mill consists of the usual reversing tables with one turn-around in the front mill table for turning the slab before and after spreading. The front and rear mill tables are each powered by two 100 hp mill type motors.

The runout table from the rear mill table to the leveler is made in two sections. Provision is made between the two sections for a cropping and dividing shear. The location is such that long plates which might be rolled from ingots could be divided for handling over the transfer and cooling bed. A hot leveler is located at the entry end of the cooling bed run-in table. This location was selected to favor the lighter gauge plates so that all possible advantage may be taken of the time available for cooling the plates as they are transferred over the cooling bed.

The cooling bed transfer serves to move the plates from the mill building to the finishing building. The runout table from the cooling bed consists of one section of roller table and three sections of chain table which serve as a layout and marking table.

This table extends from the cooling bed backward the full length of the finishing building to another transfer which serves to again reverse the direction of plate travel toward the shears.

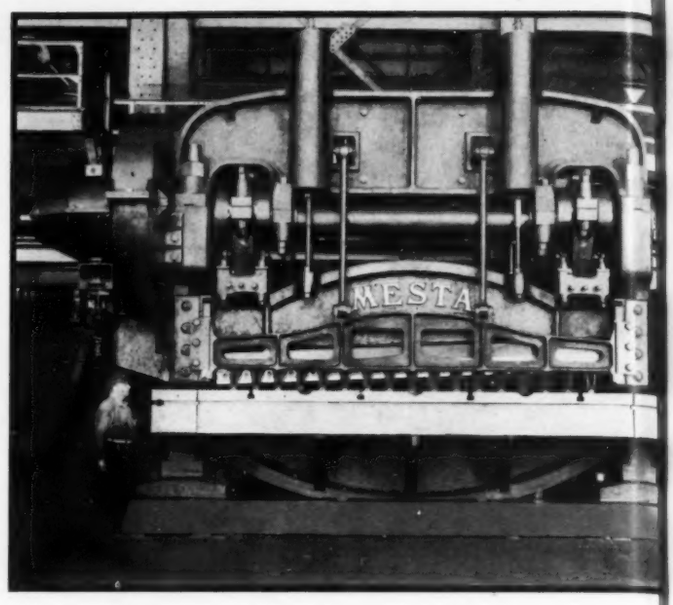


Figure 18 — Shop view of side shear installed at South African plant.

The shearing equipment consists of one end shear for a maximum plate thickness of 1¼ in. mild steel and two 180 in. long x 1¼ in. side trimming shears served by a caster bed. The end shear is provided with a motor driven scrap conveyor. Figure 18 shows a shop view of one of the side shears. The plate shears are driven by 75 hp, 750 rpm, 380 volt, 3 phase, 50 cycle, a-c wound rotor induction motors.

The drives are triple reduction flywheel drives with an overall ratio of approximately 45 to 1 resulting in a shear speed of 16½ cuts per minute with the shear running continuously. Conventional jaw type clutches with pull-out cams serve to engage the eccentric shaft when the shearing cut is made. The clutch mechanism is actuated by an air cylinder under control of a solenoid operated air valve.

A portion of the caster bed extends over the platform of a floor type scale for weighing the plates before they are lifted off for stacking and loading out. The shipping area occupies a portion of the plate finishing building about 300 ft long between the cooling bed runout and marking tables and the shipping track.

NATIONAL STEEL COMPANY OF BRAZIL

Another foreign mill shown in Figure 19 is the 72 in. wide plate mill being built in this country for the National Steel Company of Brazil at Volta Redonda, Brazil. This mill is designed to roll universal plates ¼ in. to 1 in. thick, 18 in. to 66 in. wide, up to 50 ft long for ship plate, tanks, boiler plate, structural plate, etc., sheared plates ¼ in. to 1 in. thick, 18 in. to 60 in. wide up to 35 ft long, and breakdowns ⅜ in. to 1 in. thick, 14 in. to 44 in. wide of 125 ft maximum length

for a continuous hot strip mill (for sheets and hot rolled coils for tinplate) in direct line with the plate mill stand.

The initial capacity of this mill is 47,500 metric tons per year of universal and sheared plates, 12,000 metric tons per year of strip rolled plates and 90,000 metric tons per year of hot rolled strip for sheets and tin plate. These tonnages are as rolled and not final product tonnages which would take into account average losses due to scrap, etc.

Slabs will be delivered to this mill in widths up to 48 in. and in lengths from 5 ft to 16 ft from a 40 in. slabbing-blooming mill immediately ahead of this mill and in line with it.

Provision will be made for delivery of hot slabs direct to the mill for rolling without reheating, to the heating furnace for charging hot, and for storage and conditioning in the slab yard for charging cold into the furnace.

Plates over 48 in. wide will be obtained by broadside rolling slabs of 66 in. maximum length to obtain any desired width up to a maximum of 66 in. Plates 48 in. to 66 in. wide will be limited to lengths obtainable from a 48 in. x 66 in. x 8 in. maximum slab size for broadside rolling. Widths up to 48 in. wide will be rolled from slabs ranging from 3 in. to 6 in. thick, 18 in. to 48 in. wide and 5 ft to 16 ft long.

Slabs are heated in a continuous reheating furnace, recuperative type, arranged for under and over firing, end charge and discharge, approximately 18 ft x 86 ft overall inside brickwork.

The furnace has a rated capacity of 40 net tons per hour (36 metric tons) when heating cold slabs. Provisions are made for installation of a second furnace in the future.

The mechanical equipment at the furnace consists of slab transfer entry table, slab pusher for charging hot slabs from table to transfer, slab transfer to furnace charging table, slab piling cradles, slab depiler table with elevator or pusher, double slab pusher and furnace delivery table with bumpers.

The hot slabs delivered from the furnace are conveyed over the mill approach table and the front mill table and to the mill. The mill proper is a 36 in. and 49 in. x 72 in. four-high reversing mill with attached vertical edger having a 14 in. to 68 in. roll opening. The back-up rolls run on oil film bearings, the work rolls on roller bearings. The mill is equipped with hydraulic roll balance, latch type chocks and double motor screwdown. The main drive to the work rolls is through leading spindle, mill pinions and universal mill spindles from a 5000 hp, d-c reversing motor running 50 to 106 rpm. Roll surface speed is approximately 470 to 1000 fpm.

After the plate is rolled to gauge it is conveyed through an up-cut cropping and dividing shear and plate leveler to the hot bed run-in table. Breakdowns to the strip mill continue in the same line to the strip mill approach table. All plates are transferred over the hot bed to the plate finishing line consisting of hot bed runout table, inspection table with turn-up, cooling conveyor, shear approach table, up-cut shear with gauge and piler table with side piler and cradles. Plates that are to be slit or side sheared are handled over a caster bed to a single squaring shear of 1 in. x 156 in. capacity.

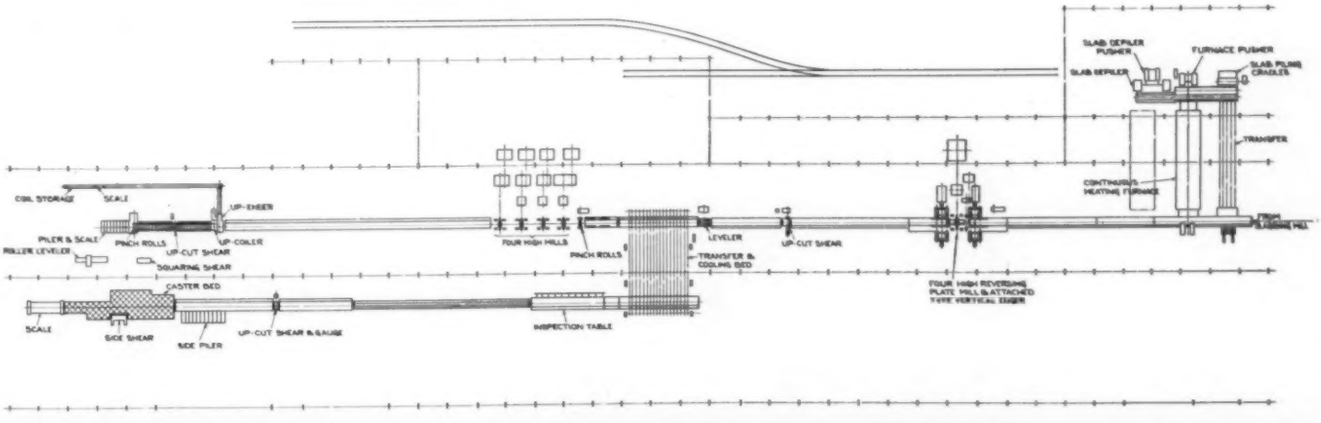
The last item of equipment in the line is a shipping scale for weighing out the finished plates.

160 IN. SINGLE STAND MILL WITH SCALE BREAKER

Figure 20 shows the general plan of a new 160 in. mill in the Pittsburgh district. On the same site, a complete new open hearth plant has been built and a new universal slabbing mill has been put into operation. This slabbing mill will serve both the new 160 in. plate mill and an existing continuous plate mill.

Three new slab yards have been laid out parallel to an existing slab yard and at right angles to the slabbing mill and plate mill buildings. Ample space is provided in these yards for slab storage, preheating and slow cooling pits and slab conditioning area. Two slab car transfers at the end of the slabbing mill building serve to the new yards. Slabs are served to the 160 in. mill heating furnaces by two transfer tracks running parallel to the plate mill line and at right angles to and across

Figure 19 — General layout of 72 in. plate mill at National Steel Company of Brazil, Volta Redonda, Brazil.



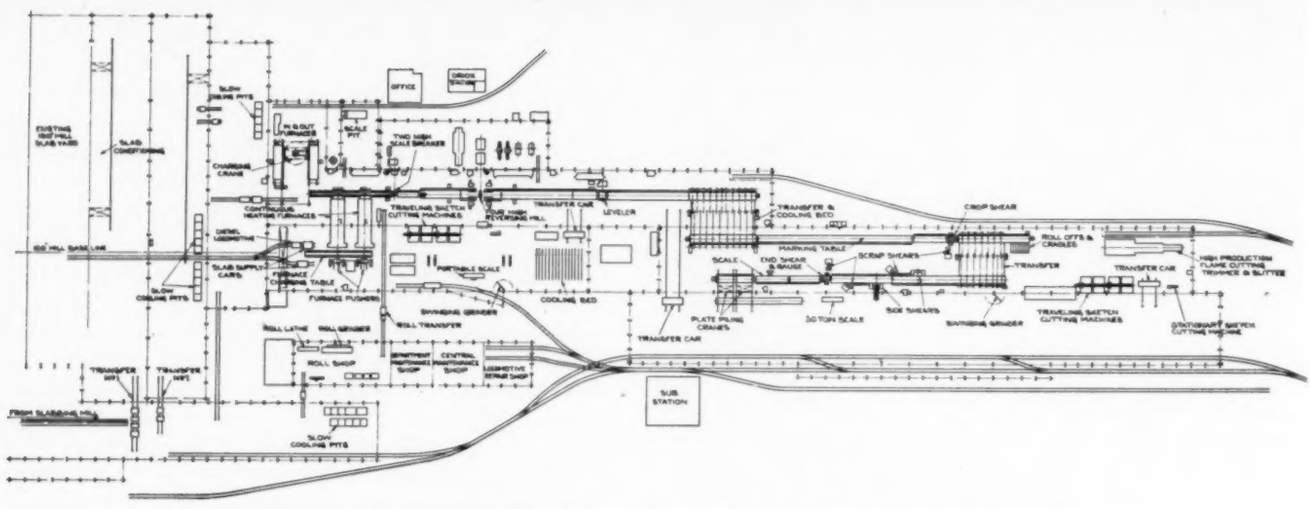


Figure 20 — General plan of 160 in. mill installed in the Pittsburgh district.

the yards. These transfers are equipped with slab shuttle cars hauled by 25 ton diesel electric locomotives.

The slab heating equipment consists of two zone controlled, triple fired, end charged, end discharged, recuperator type continuous heating furnaces and two zone controlled, end fired, side door or in-and out-type furnaces with recuperators. There are two furnaces of each type in the layout.

The continuous furnaces have an effective heating length of 80 ft and an inside width of 23 ft. They are designed for both top and bottom firing in the primary heating zone. The specified heating capacity of each furnace is 70 gross tons of steel per hour. The furnaces are designed to operate on a mixture of coke oven gas and natural gas of approximately 600 Btu per cu ft average heating value. Liquid fuel may also be used. The maximum slab thickness is 12 in.

The inside dimensions of the in-and-out furnaces are 15 ft x 49 ft 6 in., with an effective hearth length of 46 ft. The maximum size of slabs to be heated is 22 in. x 62 in. x 144 in. Each furnace is provided with two doors, each door being made up in three sections without jambs, each one of which may be operated independently. With this arrangement of doors either half of the furnace may be thrown completely open with no door frame interference whatever and the entire furnace front may be opened with no obstruction except the center jamb. Both in-and-out furnaces and continuous furnaces are provided with automatic controls.

The continuous furnaces are charged from the slab cars by a 20 ton overhead furnace charging crane with slab handling tongs or lifting magnet. The slabs are deposited on the furnace charging table and are fed through the furnaces by double rack type pushers arranged to feed two rows of slabs through each furnace. Slabs discharged from the delivery end of the continuous furnaces slide down delivery chutes to the furnace delivery table against spring-backed bumpers. The in-and-out furnaces are charged and the mill served from these furnaces by a stiff leg swivel charging crane running between the two furnaces and effectively covering furnace hearth area, charging floor between furnaces, slab transfer track and the end of the furnace delivery table upon which the hot slabs are deposited by the crane.

The scale breaker stand is a two-high stand with rolls 36 in. in diameter x 70 in. length of body, driven by a 1600 hp, 492 rpm, 6600 volt, 3 phase, 25 cycle, a-c wound rotor induction motor through a double reduction flywheel gear drive, universal leading spindle, mill pinions and universal mill spindles.

The main mill stand is a reversing four-high stand with back-up rolls 59 in. in diameter x 154 in. length of roll body, supported in oil film bearings. The work rolls are 38 in. in diameter x 160 in. long, with four row tapered roller bearings. The back-up rolls are anchored to the mill housing through two-row steep angle tapered thrust bearings. Top rolls are balanced by hydraulic plungers mounted in the bottom back-up bearing boxes. Figure 21 shows a shop view of the housings erected on master shoe plates used for assembly purposes. The back-up rolls are moved into and out of the mill on a motor driven slide. The work rolls are changed by a "C" hook with motor driven shift of the hook suspension between the center of gravity of the empty rig and the center of gravity of the loaded rig.

The mill screws are operated by two 150 hp mill type motors supplied by a variable voltage motor-generator set with shovel generator characteristics. The maximum motor speed is 850 rpm. A thirteen-pass two-schedule preset automatic screwdown control with optional manual control is provided for this mill. Provision is made so that one schedule can be set up while another is being run.

The main motor drive consists of two 5000 hp, 700 volt, d-c reversing motors, one driving each roll without mill pinions through universal spindles 36 ft long, center to center of universals.

The two motors have a combined full load torque of 1,312,000 lb-ft at 40 rpm and a maximum working torque of 2,953,000 lb-ft at 40 rpm. Figure 22 shows a similar drive. The roll surface speed is 400 to 800 fpm.

The main drive motor generator set is a four-unit flywheel set consisting of one 9000 hp, 371 rpm, 6600 volt, 3 phase, 25 cycle, a-c wound rotor induction motor with flywheel having a total energy content of 245,000 hp-sec at 375 rpm. There are three 3000 kw, 700 volt generators.

The mill is served by front and rear reversing tables each driven by four 50 hp mill type motors supplied by a variable voltage motor generator set which is a duplicate of the one that supplies the screwdowns. The mill approach and runout table motors are also supplied from these two motor generator sets each of which is a five-unit set consisting of one 800 hp, 6600 volt, 3 phase, 25 cycle, 750 rpm synchronous motor with two 150 kw and two 200 kw, 250 volt, d-c generators of shovel generator characteristics. Turning the slabs on front and rear mill tables for spreading passes is accomplished by tapered rollers, alternate rollers being on separate motor drives. Substantial manipulating side guards are provided on each side of the mill for squaring and centering the slabs.

From the mill stand the plates are conveyed through a hot leveler to a transfer and cooling bed 108 ft wide at the end of the mill building. Ahead of the leveler there is a section of table arranged so that heavy plates may be lifted off the table with lifting hooks and loaded onto a motorized transfer car which serves a flame cutting area in the adjoining building. The cooling bed at the end of the table run from the mill is of the chain and grid type and serves to cool and transfer the plates to the shear building where they travel over a marking table to an end shear for cropping the front end or dividing the plate. This shear is located near the entry end of a transfer run-in table which serves a chain transfer 72 ft wide. Beyond the transfer and in line with the marking table the transfer run-in table is extended and roll offs and cradles approximately 40 ft long are provided for taking off plates that are to be finished by flame cutting.

The transfer runout table doubles back in the direction of the mill, along one side of the shear building and here the principal shearing equipment is located.

There are three shears, two side shears with knives 180 in. long and one end shear with knives 160 in. long. The crop shear at the entry end of the cooling bed transfer is a duplicate of this end shear and all four shears are practically alike except for the length of the knives. The shears have capacity for shearing mild steel plate up to 1½ in. thick. The design of the shear units themselves is unique. Figure 23 shows the front view of a similar shear. The shears operate on the hydraulic principle with self-contained pump and motor drive. Each shear has two main hydraulic cylinders with plungers of equal area, one exerting downward pressure against each end of the shear ram. Equal hydraulic displacement in the two main cylinders will produce a parallel downward movement of the ram or upper knife block during the shearing stroke. As the cut travels along the raked upper knife from one end to the other the reacting pressure on the cylinders first comes mainly on one cylinder as the knife engages the plate at that end, then it is shared equally by the two cylinders when the cut reaches the center of the knife and finally comes mainly on the other cylinder as the cut is finished near that end of the knife.

Figure 21 — Shop view of housings for 160-in. plate mill, erected on master shoe plates used for assembly purposes.

The equal hydraulic displacement required to produce parallel movement of the upper knife is delivered to the two main cylinders by a single stroke duplex hydraulic pump having two cylinders of exactly equal displacement. These cylinders are piped separately, one to each of the shear cylinders.

The three shears with shear tables and auxiliary equipment constitute a completely mechanized shearing

Figure 22 — Twin-motor drive of the type used on the new 160 in. mill.

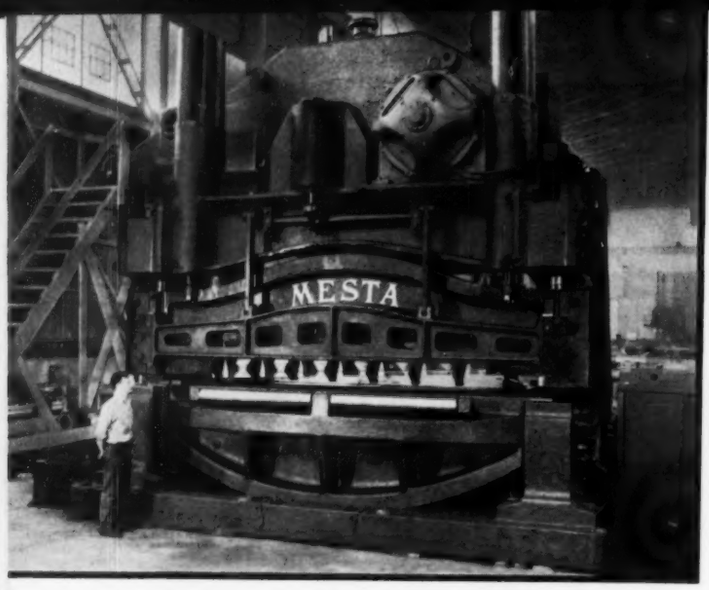


Figure 23 — Shop view of plate shear designed for shearing mild steel up to 1½ in. thick.

line as shown in Figure 24. The side shears are located one on each side of the shear table and are staggered in such a way that one side of the plate can be trimmed completely to guide lines on the table rollers or to a marked line on the plate, before the plate is moved transversely on the table to trim the other side. Transverse movement of the plate, aligning and skewing are accomplished by a series of electromagnets located beneath the table and between the table rollers. There are six magnets for each shear and an additional magnet at the entry end of the outfit. These magnets are moved across the tables by screws with individual motor drive enabling the operator to align or skew the plate. Each magnet is mounted in a frame which can be elevated a short distance above the top of the table rollers by means of an eccentric cam and double acting cylinders served by a motor driven pump system.

To assist in lining up the untrimmed edge of the plate parallel to the trimmed edge a mechanical width gauge is provided at the second side trimming shear. After the plates have been side trimmed they continue down the table to the second end shear where they are cut to length. This shear is equipped with squaring pushers on the table and a motor operated shear gauge for mechanically gauging to predetermined lengths.

Besides facilitating the cutting of rectangular plates by mechanical handling the individually operated screws with their magnets enable the operator to move the plate out of line at will for skew cutting of some plates.

Having been finish-sheared to size the plates move on over a scale table (where they are individually weighed) to a section of table covered by two transverse piling cranes. These cranes serve to transfer the plates one at a time to the shipping building where they are piled by the same cranes on conveyor tables for rolling the piles out from under the piling cranes where they can be reached by the overhead cranes in the shipping building for stocking or loading out.

Vertical scrap cutting shears are provided for cutting the scrap from cross conveyors at each end shear. Each scrap shear is powered by a 150 hp, d-c mill type motor for start-stop service. The control is arranged so that scrap shear and conveyor can start and stop together or separately or both conveyor and shear can be left running so as to cut the scrap into lengths that are roughly determined by the relative speeds of conveyor and shear. The scrap is collected in buckets by gravity chutes from the scrap shears. Provision is made for catching test pieces as they are sheared.

The scrap from each side shear is also taken by conveyors which slope downward to about floor level where it is cut by lever shears motored by start and stop d-c mill type motors. No portion of the scrap shear equipment for the side shears projects above the top of the roller table. This makes it possible for long plates to overhang the table at this point when making skew or angle cuts on either side shears or end shears. The scrap is collected in the same manner as for the vertical scrap shears at the end shears.

Quite extensive flame cutting equipment has been provided for this mill. An area approximately 375 ft long x 110 ft wide has been provided opposite the mill stand in an extension of the building that houses the continuous heating furnaces. This area can be served with plates by a two hundred ton motorized broadside transfer car arranged to handle heavy plates from the mill building where they are lifted from the mill runout table by a special lifting rig. Provision is also made for transferring plates either way between this building and the shipping building on a 200 ton standard railway car. Cooling skids for hot plates and annealing furnaces also are provided in this building along with a portable scale and a swing grinder. The principal flame cutting equipment consists of traveling pantograph sketch cutting machines and stationary pantograph sketch cutting machine.

This flame cutting equipment is duplicated in another area approximately 275 ft long x 110 ft wide beyond the transfer to the shearing line. Plates may be taken from the roll off cradles at the end of the run of tables beyond the transfer. Finished plates are transferred to the shipping building by a second motorized broadside transfer car which is a duplicate of the one previously mentioned.

In addition to the pantograph sketch cutting equipment, a high production or flame-cutting trimmer and slitter is being installed in this area. The main features of the flame cutting carriages used on this unit have been described previously in this paper. The arrangement of the tables serving the flame cutting carriages is worthy of note. They are designed to handle plates 40 ft long up to 3 in. thickness, and consist of three sections, each approximately 40 ft in length.

The first section is an idle roller table which serves as a loading table. The plates are deposited on this table by crane in such a position that they can be advanced to the working area by a chain driven pull off carriage running down the middle of the table. The entire table is mounted on wheels running on transverse tracks so that the plate can be moved laterally across the end of the working area for proper positioning relative to the cutting torches. The middle section of table under the working area is also approximately 40 ft long. This table has chain driven disc rollers and is arranged to pivot at the entry end with a 6 in. movement in each direction at the delivery end. This

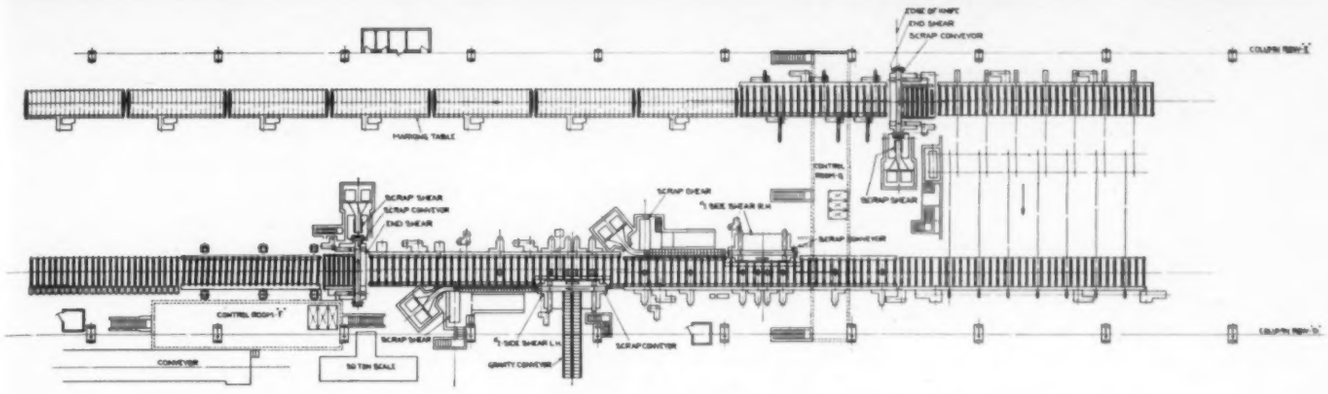


Figure 24 — Plan showing arrangement of shears and tables in 160 in. mill to form a completely mechanized shearing line.

allows convenient aligning of the plate with the cutting torches. The flame cutting carriages work over this table and cover the entire area by running on tracks outside the table. Three carriages are provided one on each end with cross travel for end cutting and one in between which carries the torches that are used for longitudinal cutting; that is, edge trimming or slitting. After the plate has been cut it is rolled off onto a third section of table also about 40 ft long consisting of idle gravity rollers from which it is lifted by crane.

An interesting mechanical marking machine has been provided at the marking table. This machine runs on rails along the entire length of the table. Indexed longitudinal and transverse movements enable the operator to measure and mark off mechanically with hot chalk on the plates any desired size and shape of rectangular plate.

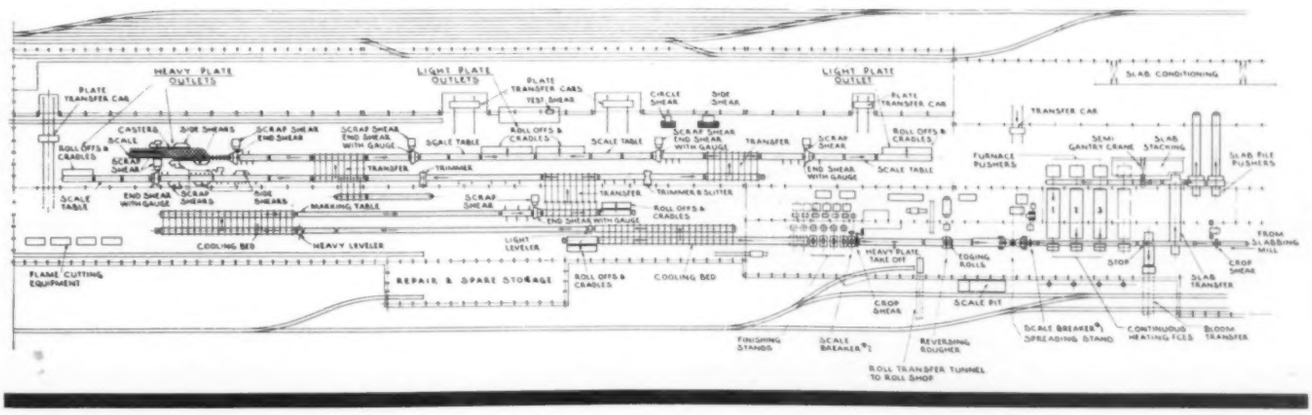
Other auxiliaries such as the descaling system, grease and oil lubrication systems, water circulating, cooling and scale flushing systems are interesting but lack of space and time prevents further description.

132 IN. SEMI-CONTINUOUS MILL

The 132 in. continuous plate mill now being installed west of the Rocky Mountains is the widest continuous mill as well as the most complete and extensive of all the plate mills. The arrangement of the stands as shown in Figure 25 follows the conventional arrangement of most of the so-called continuous mills in that the roughing end of the mill is not continuous. It consists of a scale-breaking stand for cracking up the furnace scale, a non-reversing spreading stand and a universal four-high reversing stand. The finishing end consists of a secondary scale breaker and a continuous train of four four-high finishing stands with provision for two additional stands in the future for rolling lighter gauge products.

The mill is supplied with slabs up to 62 in. wide by a universal slabbing mill located just ahead of it and in direct line so that plates may be rolled direct from the ingot heat where feasible. Other slabs are delivered from the slabbing mill to a transfer which is arranged to feed the heating furnace charging table in the slab yard. The slabs may go to the left to be charged directly into the reheating furnaces with their residual slab heat or they may go to the right to be piled and transferred to a second slab yard for storage and flame conditioning. The flame conditioning area in this yard is covered by half-gantry cranes. Slabs to be charged into the heating furnaces are transferred back into the first mentioned yard on car transfers between the two yards. Slabs are stacked by the traveling cranes serving this yard in a

Figure 25 — General layout of 132 in. continuous plate mill now being installed west of the Rocky Mountains.



stacking area covered by a semi-gantry crane by means of which the slabs are deposited one at a time in proper order on the furnace charging table.

Three continuous heating furnaces are being installed with provision for a fourth. These are served by the usual type of double furnace pusher. Heated slabs are discharged against spring bumpers at the furnace delivery table and proceed to the primary scale breaker.

The primary or No. 1 scale breaker is a 36 in. x 70 in. two-high stand with composition bearings. It is powered by a 1250 hp, 240 rpm, 6600 volt, 3 phase, 60 cycle, a-c wound rotor induction motor driving the mill rolls through a single reduction flywheel drive having a total energy content of 25,000 hp-sec at light load speed. The rolls lift to a maximum opening of 12 in. Roll surface speed is approximately 300 fpm.

The spreading stand has back-up rolls 56 in. in diameter x 130 in. length of body running in oil film bearings, and work rolls 42 in. in diameter x 132 in. length of body running in babbitted bearings. The back-up rolls are equipped with outboard roller thrust bearings. This stand is driven by a 4500 hp, 150 rpm, 6600 volt, 3 phase, 60 cycle a-c wound rotor induction motor with a 20 ft diameter segmental cast steel flywheel of 45,000 hp-sec total energy content mounted on the armature shaft. The drive is through a single reduction double helical gear set with main gear 17 ft pitch diameter x 54 in. face.

Turn-arounds are provided on each side of the spreading stand for turning the slab before and after spreading. Though this is a non-reversing stand a second spreading pass may be taken if desired by returning the slab after the first pass through open rolls to the entry side of the mill by means of a link type mechanical pusher. A similar pusher is provided on the entry side of the mill to assist in squaring and entering the slab for the spreading pass.

The reversing stand has the same size backing rolls as the spreading stand. The working rolls are 38 in. in diameter x 132 in. body length, and run in four row tapered roller bearings. The horizontal rolls of this stand are driven through mill pinions by a 7000 hp, 700 volt, double armature reversing motor running at 25 to 60 rpm. This motor develops a full load torque at 25 rpm of 1,470,000 lb-ft. Figure 26 shows a shop view of typical plate mill housings. The vertical edging rolls of this universal stand are mounted in a separate housing secured to the entering side of the horizontal roll housings on close centers. The vertical rolls are top driven through vertical spindles from overhead worm drives mounted along side the horizontal roll screwdown. The motor driving these edging rolls is a reversing mill type motor 250 to 650 hp, 375 to 1050 rpm, 230 to 600 volts.

The horizontal roll screws are driven by two 100 hp mill type motors from a variable voltage motor generator set, developing a maximum screw travel speed of 51 in. per minute at top voltage and top motor speed. An eleven-pass two-schedule preset automatic screwdown control with optional manual control is provided for this mill. Provision is made so that one schedule can be set up while another is being run.

Reversing mill tables on either side of this stand are each driven by two mill type motors 75 to 150 hp, each from the same variable voltage motor generator set which supplies the vertical edger motor and horizontal roll screwdown motors.

The four finishing stands which form a continuous train have back-up rolls 59 in. in diameter x 130 in. length of roll body running in oil film bearings. The work rolls are 30 in. in diameter x 132 in. length of body and run in four row tapered roller bearings. Each of these stands is powered by a 5000 hp, 600 volt, 125-245 rpm, d-c motor driving the rolls through mill pinions and a single reduction single helical gear drive.

A two-high stand 25½ in. x 132 in. serving as a secondary scale breaker is located just ahead of the finishing train. It is driven by a 500 hp, 600 volt, 150 to 600 rpm, d-c motor.

There are five large motor generator sets supplying power for the d-c main motors and principal mill auxiliaries. No. 1 set consists of a 7000 hp, a-c motor with flywheel and four 1750 kw generators for the reversing mill main motor. No. 2 and 3 each have one 9800 hp, 6600 volt, a-c synchronous motor driving two 3500 kw, 600 volt, d-c generators for the finishing stands and No. 2 scale breaker main motors. No. 4 set is powered by one 1250 hp, 6600 volt, a-c synchronous motor driving one 500 kw generator for the vertical edger, two 100 kw generators for the reversing mill screwdown, one 150 kw generator for the front mill table and one 150 kw for the rear mill table. No. 5 set has a 1000 hp, 6600 volt synchronous motor driving four generators for the mill runout tables. Three of these are 250 kw generators and one is a 60 kw generator.

Provision is made for the future addition of two more finishing stands for rolling down to lighter gauges. A flying crop shear is provided ahead of the No. 2 scale breaker for squaring front or rear ends of the plate before entering the finishing train. A heavy plate take off is provided in the table between the roughing and finishing stands.

The runout table from the finishing stands conveys the plate to a chain and grid type cooling bed 260 ft wide x 21 ft, 8 in. center to center of run-in and runout tables. This table has at its extreme end beyond the cooling bed a set of roll offs and cradles for heavy plate. The runout table from this cooling bed has a light plate leveler at its entry end and a heavy plate leveler at its delivery end just ahead of a second cooling bed. This bed is similar to the first except for the distance between table centers which is 32 ft 4 in. The runout table from this bed doubles back in the direction of the mill stands and forms a layoff or marking table. At the end of the marking table there is located a cropping and dividing shear and beyond the shear a chain transfer to the shear building. At the end of this table is another set of roll offs and cradles used primarily for reclaim plates.

From the transfer the flow of material divides. Plates moving to the right pass through a rotary side trimmer with arbors arranged for slitting knives. Behind the trimmer the plates are again transferred to a table where they may move in either direction to one of two light plate outlets each consisting of an end shear, gauge, scale table, roll offs and cradles. Figure 27 shows a rotary trimmer and slitter of this type.

Plates moving to the left beyond the central transfer pass through a rotary side trimmer equipped with overhung knives and then proceed to another transfer

with tables running to the right to serve a third light plate outlet which is a duplicate of the two previously described.

Heavier plate proceeds either in a straight line over the transfer run-in table to a mechanized shear line or across the transfer and to the left to a caster bed area.

The mechanized shearing line consists of two 180 in. side shears and one end-shear 132 in. wide complete with mechanical handling, scrap shearing, gauging, weighing and roll off equipment very similar to that of the 160 in. mill just described.

There are three shears in the caster bed area: one end-shear 132 in. wide receiving plates from the approach table and two side-shears 180 in. wide located in offset or staggered relation to each other, one on each side of the caster bed. Both end-shear and side-shears are provided with scrap cutting shears and conveyors which are practically duplicates of those in the mechanized line. All of the shears are of the self-contained electro-hydraulic type described in detail previously in this paper. A floor type scale is provided under a portion of the caster bed area for weighing out finished plates.

Rejected plates that can be reclaimed by reshearing to smaller dimensions are taken from the roll-offs at the end of the run of table beyond the marking table and the central transfer, and are transported by crane to a floor area opposite the marking table and in the same building. Here they may be stacked for further inspection, classification and marking. Adjacent to this floor area is a conveyor table which is used for receiving the plates to be reclaimed and on which further marking and lay off work may be done. From here the plates are transferred to the shear building by a chain transfer after marking and re-enter the main stream of plates proceeding to the mechanized shearing line or to the

Figure 26 — Shop view of housings of the type used in ← 132 in. continuous plate mill.

Figure 27 — Shop view of rotary trimmer and slitter of ↑ the type installed in 132 in. continuous plate mill.

caster bed shears at a point on the table opposite the transfer which leads to the caster bed shear approach tables.

Test pieces that have been cut out roughly by the scrap shears at the guillotine end shears are taken to a nearby physical laboratory where a test shear is located which is used for finish shearing the test pieces preparatory to final shaping. This is a vertical motor driven guillotine shear with flywheel drive transmitting the power from the motor and wheel through a friction clutch and train of gears to the main eccentric shaft. A convenient table equipped with a hand clamping arrangement facilitates the safe handling of the small specimens from which the test pieces are cut.

An additional side-shear 180 in. wide is used for slitting and dividing and for hand shearing of sketch plates and other special shearing jobs. This shear is a duplicate of the other four 180 in. side-shears in the mechanized and caster bed lines. It is located along the line of columns between shear building and shipping building and is served by its own caster bed to which plates are handled by crane from piles in the adjacent floor area.

There are in all three main shearing outlets for light plates and two for heavy plates. The principal shearing equipment consists of a total of six 132 in. end-shears, five 180 in. side-shears and two rotary trimming shears, one of which is also equipped with slitting knives.

In addition to this array of shears for straight line cutting there is one circle cutting shear capable of cutting plates up to ¾ in. thick to curved and irregular lines. It is equipped with a circle cutting attachment to assist in cutting circular blanks up to 12 ft in diameter for tank heads and similar purposes. This shear is also served by a caster bed. It is located between the shear building and the shipping building.

A flame cutting area is arranged at the extreme end of the cooling bed building where a high production flame cutting trimmer and slitter and other flame cutting equipment are to be installed. Plates that are to go to this department come from the take off and roll off outlets previously mentioned. These are located in suitable locations in the table runs before the plates reach the shearing area.

A 40 ft motorized broadside transfer car serves the flame cutting area and the heavy shearing outlets by crossing the shear building from the flame cutting area of the cooling bed building to the shipping building. Three other similar transfer cars, one 40 ft long and two 60 ft long, are used to move finished plates from the shear building to the shipping building. These are located at points convenient to the several sheared plate outlets.

The floor of the shipping building is 4 ft higher in elevation than the general floor level of the shear building and other buildings. A loading and shipping track at general yard levels runs the entire length of the shipping building and serves as a loading track which is depressed relative to the higher level of the shipping building floor. The transfer cars also enter the shipping building at the lower level. The magnitude of the entire layout may perhaps be best appreciated by the fact that the shear and shipping buildings are each 1850 ft long, or well over a third of a mile.

The entire length of the table run throughout the plate mill from the slab transfer ahead of the slab heating furnaces to the roll offs at the shear outlets adds up to approximately one and one-tenth miles. The total area of buildings under roof pertaining to the plate mill alone, including slab storage area but not including the slabbing mill building, roll shop or any shop or service buildings, covers a floor area of approximately 22 acres.

All of the plate mills described in the course of this paper will soon be in production. They will serve the country and our allies well in the common effort to put the initial "V" in our final victory.

DISCUSSION

PRESENTED BY

R. H. WRIGHT, Steel Mill Engineer, Industrial Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

R. H. Wright: Previous to the start of the recent plate mill construction program, plate mill facilities had been expanded and improved at a moderate rate. With occasional changes in equipment, the demand could be supplied quite easily by existing plate mills and such wide strip mills as had plate handling facilities. Plate was one of the earliest forms of rolled steel products and most of the present types of plate mills were developed years ago and electric drive had been applied to all types. So to increase output for war needs it was only necessary to install more mills of types already available and tried out.

The following list of typical installations will indicate the wide range of types on which experience was available.

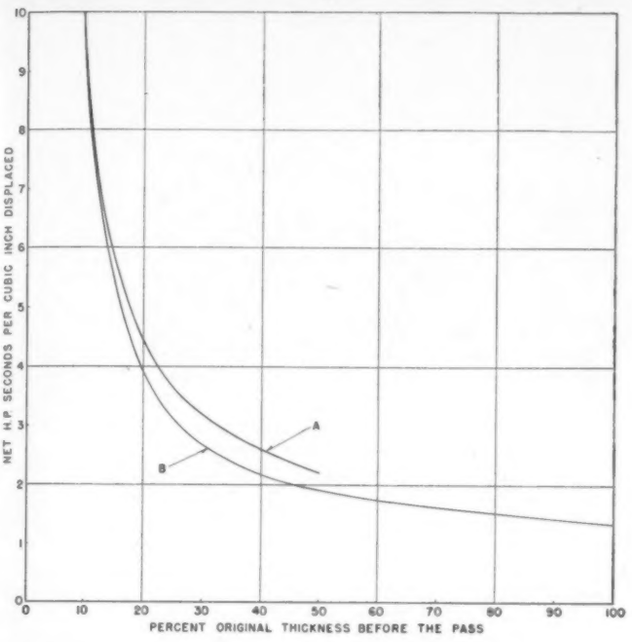
1. A 36 in. two-high universal mill with reversing electric drive, installed in 1906.
2. A 60 in. three-high universal mill with electric drive, installed in 1909.
3. An electrically driven 84 in. three-high, two-stand tandem mill installed in 1913.
4. A 206 in. four-high, engine driven reversing mill installed in 1916.
5. A 160 in. three-high mill installed in 1917.
6. A 60 in. two-high universal mill with reversing drive, installed in 1920.
7. An 84 in. two-stand tandem mill with two-high reversing rougher and four-high reversing finisher, installed in 1926.
8. A 100 in. tandem mill with four-high reversing rougher, installed in 1936.

A number of the strip mills rolled plate but until the war construction program started most plate mills of more than 90 in. width had been three-high with induction motor drive and with flywheel to equalize the peaks. In such a combination the flywheel carries most of the load on the short passes and the motor carries most of the load on the long passes. There was seldom any question about either the continuous capacity or the peak capacity of such a drive so there had been little occasion to make detailed tests of power requirements.

There were two notable exceptions to the general practice. One was the 206 in. engine driven mill and the other was the 100 in. four-high reversing roughing mill. Indicator tests had shown that the engine on the 206 in. mill had never exerted more than 1,250,000 lb-ft torque at the rolls. This mill had never been particularly limited by lack of power although the number of passes made on heavy plates was greater than normal. On the other hand the 100 in. reversing rougher had a 7000 hp, 40/80 rpm motor drive with a maximum operating torque of 2,070,000 lb-ft and a maximum circuit breaker torque of 2,500,000 lb-ft. This motor had frequently been required to exert its maximum operating torque.

To secure simple and flexible equipment which could be installed in a minimum of time, single stand four-high reversing mills were selected for a number of the new installations. In one instance the new mill operates entirely alone and breaks down and finishes directly from slabs. In other cases the new mill is preceded by an existing three-high stand which serves as a rougher. In view of the limited experience with this type of layout on very wide plate there was naturally some question as to the power which should be applied to the new four-high stands. The situation was somewhat confused by the wide differences in power used by the 206 in. steam driven mill and the 100 in. electrically driven mill mentioned above.

The first wartime installation was the 110 in. four-high mill at the Steel Company of Canada. The working rolls are 38 in. in diameter and are driven by a 5000 hp, 35/80 rpm reversing motor. This mill has a vertical edger and scale breaker with 40 in. rolls driven by a 500 hp, 125/406 rpm reversing motor. The complete electrical equipment is described by Porter, Price and Kenyon in the 1942 A. I. S. E. Yearbook. As outlined in this paper, drafts of 1 in. on 70 in. width, ¾ in. on 88 in. width and ½ in. on 98 in. width can be made



Curves giving specific power consumptions of two plate mills. These values are used in the formula: $T = 275\,CD\,(A_1 - A_2)(A_2 \div A_1)$ where T = motor torque, lb-ft; C = factor from curve; D = diameter of roll, in.; A_1 = area of section before pass, in.; A_2 = area of section after pass, in.

with torques well within the 1,700,000 lb-ft operating torque capacity of the main motor.

Next came the Tennessee Coal, Iron and Railroad Company's 140 in. four-high mill described by J. D. Clark in the Iron and Steel Engineer for October, 1943. This mill operates as a finishing stand for a 110 in. three-high mill which had been in operation since 1918. The working rolls of the new four-high stand are 38 in. in diameter by 140 in. long. In selecting the drive it was desired to provide power for finishing plates which had been roughed down from slabs up to 15 in. thick. A 7000 hp, 35/70 rpm single armature reversing motor with 2,362,000 lb-ft current limit torque and 2,887,000 lb-ft circuit breaker torque was selected. Most of the work in this mill has been on slabs of medium thickness and the loads have been moderate.

A similar arrangement was used by the Lukens Steel Company for a new 120 in. four-high stand. The roughing passes are made in a 112 in. three-high mill which had previously been turning out finished plate. The 120 in. mill is driven by a 7000 hp, 35/70 rpm single armature reversing motor. The plate entering this mill has been broken down in the 112 in. mill from heavy slab ingots. Reductions of ½ in. to 1 in. are made regularly in the 120 in. stand. The loads are heavy but are within the rated capacity of the drive.

Before either the Tennessee Coal, Iron and Railroad Company's 140 in. mill or the Lukens' 120 in. mill were in operation, it became necessary to decide on a drive for a 160 in. four-high mill. Much of the test data available at that time had been taken on old mills and on narrow widths. To check existing data and to determine whether a wide mill had any peculiar power requirements a test was run on the four-high roughing stand of a 100 in. tandem mill. This mill has a scale breaker, a spreading stand and a squeezer, all located ahead of the roughing stand. The slab is reduced to nearly half its original thickness before entering the roughing stand. Due particularly to the cooling effect of the squeezer, the steel is rolled at a lower temperature than if all roughing passes were made in the four-high reversing stand.

Curve A of the accompanying graph shows the results of the test on this stand. This curve gives the net horsepower-seconds per cubic inch displaced for the low carbon slabs rolled during the test. Curve B, included for comparison, gives the same data for a 30 in. two-high universal mill rolling direct from slabs.

One of the interesting features of the test on the 100 in. mill was that a light draft in the first pass consistently required more power than heavier succeeding passes. This had previously been noticed by the mill operators and had given rise to a feeling that somehow a wide mill might require more power per unit of work done than a narrow mill. After studying the test results it was decided that the cooling of the surface of the slab in the squeezer was responsible for this condition. After the first pass the temperatures were equalized and the unit energy requirement became more nearly normal. It was evident that power data for the first pass applied only to a particular mill layout, so it was disregarded in plotting the curve A. It was also evident that under similar rolling conditions curve A could be expected to be no higher than curve B.

Based on this data, a 10,000 hp, 40/80 rpm twin-motor drive was selected for the 160 in. mill. This is the first application in this country of twin-motor drive to a plate mill for both roughing and finishing work.

A universal plate mill which went into operation in 1930 at the Gulf States plant of Republic Steel Corporation has a variable voltage screwdown. This was the first application of variable voltage control to a mill auxiliary drive. Due to low activity in new construction, it was not until recently that variable voltage auxiliaries were again used on a plate mill, although the idea was quite generally adopted for blooming and slabbing mills. The experience on blooming and slabbing mills demonstrated the advantages of variable voltage for auxiliaries. Most of the three-high and four-high plate mills installed recently therefore have variable voltage auxiliaries.

Among the major problems of plate mill operation are those of obtaining high output of accurately rolled product with frequent changes of schedule. To simplify these problems a number of the new mills have been equipped with automatic screwdown control. Automatic preset screwdown equipment has been built in a number of forms but the basic elements are the same for all types. There is a limit switch which is driven in synchronism with the screwdown mechanism. A plug board or similar device makes it possible to set up a schedule of passes for each order. A master switch or a set of pushbuttons permits the operator to advance the screwdown through the schedule in accordance with the plug board settings and to reset the screws after each plate is finished. Variable voltage control has been found to be most effective in obtaining quick and accurate settings with this type of control.

Plate Rolling Practice

by Louis Bunting and T. T. Watson

SUPERINTENDENT OF PLATE MILLS — DIRECTOR OF RESEARCH

LUKENS STEEL COMPANY

COATESVILLE, PENNSYLVANIA

▲ FOR over one hundred years, plates have been rolled in Coatesville in what is known today as Lukens Steel Company. With no natural resources in the Coatesville district for the manufacture of iron or steel, the outstanding asset is the skill of the men to perform the many difficult operations to make a successful product, and plate mill rolling practice is no exception.

Throughout the years, various types of mills have been installed, and various rolling mill practices tried, including slabbing mill practice, but today the entire practice at Lukens Steel Company is based on rolling ingots direct to plate. Most of the large companies use the slabbing mill practice, in which the ingot is rolled to a slab thickness, then reheated and rerolled to plate. It is not economically feasible to justify a slabbing mill in a plant such as Lukens where there is no large scale constant plate size production — in truth, Lukens is a jobbing mill.

As stated above, our rolling mill practice is to roll ingots direct to plate and we have found that bottom poured ingots give definitely better results than top poured ingots. One of the most outstanding requirements of steel plates is good surface quality, and in rolling ingots direct to plate, bottom poured ingots are far superior to top poured ingots. Approximately 70 per cent of the ingots rolled on our mills is rimmed steel, with the balance made up mostly of killed or hot topped steel (carbon and low alloy) and some semi-killed steel.

Presented before A. I. S. E. Philadelphia District Section Meeting, January 8, 1944

DESCRIPTION OF MILLS

Universal mill — This is an old type three-high mill, having a maximum plate width of 48 in. and a minimum plate width of 7½ in. x ⅜ in. thick. The minimum gauge that can be rolled in this mill is ¼ in. The top and bottom rolls are 74 in. long x 28 in. in diameter, weighing 20,000 lb, and the middle roll is 74 in. long x 21 in. in diameter, weighing, 10,350 lb. The vertical rolls consist of four rolls, two on each side of the mill. The working surface of the rolls is 17½ in. in diameter. This mill can take a 20 in. thick ingot with a maximum weight of 10,000 lb. A side reduction of from three to four inches can be made with the vertical rolls in this mill.

84 *in. mill* — The 84 in. mill consists of two reversing stands, electrically driven. The first stand consists of two rolls 84 in. x 34 in. The second stand consists of a four-high mill, two working rolls 84 in. x 23 in., weighing 14,000 lb and two backing up rolls 84 in. x 40 in., weighing 37,000 lb each. The maximum ingot weight that can be rolled in this mill is 4500 lb. The minimum gauge plate that can be rolled in this mill is 12 gauge.

120 *in. mill* — This is a new mill that was put into operation in October, 1943, consisting of one 112 in. roughing stand, electrically driven, and a 120 in. finishing mill, electrically driven. The roughing stand was originally our 112 in. three-high mill with a top and bottom roll size of 112 in. x 36 in. and a middle roll 112 in. x 20 in. Immediately behind the 112 in. roughing stand is an edger with rolls 42 in. in diameter and 33 in. high. This edger is being used to reduce the side scrap and to maintain uniform sides on the plates.

T. T. WATSON

LOUIS BUNTING

PURDY PIX

The finishing stand is a four-high electrically driven mill. The backing-up rolls are 120 in. x 54 in., weighing 108,000 lb each. The working rolls are 120 in. x 36 in., weighing 46,000 lb each. This stand also has a set of edging rolls on the front of the mill, 30 in. high and 24 in. in diameter. This edger is used to maintain the edge prepared by the large edger. There are two removable side guards on each side of this mill to ensure that the plate is always centered in the mill.

140 *in. mill* — This is an old type steam driven three-high mill. The top and bottom rolls are 140 in. x 34 in., weighing 55,500 lb each and the middle roll is 140 in. x 22 in., weighing 17,500 lb each. This mill is used both as a plate mill and as a break-down mill for the 206 in. plate mill. A fluted center roll is used when this mill is used as a break-down mill.

206 *in. mill* — This is a four-high single stand steam driven reversing mill. The backing-up rolls are 206 in. x 50 in., weighing 138,000 lb and the working rolls are 206 in. x 34 in., weighing 68,000 lb each.

ROLLING MILL PRACTICE

The factors that influence the quality of the product from a steel plate rolling mill are as follows:

1. Surface quality — (Free from defects and rolled-in oxide)
2. Dimensions — (Length, width and gauge)
3. Flatness
4. Yield

In a jobbing mill it is not always possible to take ingots from the open hearth and charge them directly into the soaking pits or heating furnaces, with the result a large number of ingots are charged cold. Before proceeding to the rolling mill practice, it might be well to state that there are two very important requisites prior to rolling in order to obtain a good product, namely good quality steel and good heating practice. Our heating practice is controlled by giving the heater a heating schedule for each heat of steel and a corps of observers is employed to check temperatures and heating schedules. For some special alloy steels it is necessary to cool down the soaking pit before charging the ingots and the final rolling temperature is obtained by heating through a prescribed heating cycle.

The hot rolling of ingots direct to plate causes concentrated wear on the center of the working rolls due to the differential between the width of the ingot and the finished plate. Consequently measures must be taken to counteract this condition. The width of the mill will also influence this factor because the spring of the rolls increases with the width of the mill. To overcome this difficulty it is necessary to taper the working rolls to meet specific conditions. No definite rule or formula can be established that will apply to all mills. It is therefore necessary to taper or crown the rolls slightly, otherwise the resultant plates will be much thicker through the middle of the longitudinal axis of the plate than the edges. When you consider that a roller can only determine the gauge thickness of the hot rolled plate on the edge of the plate, it can be readily seen that this is quite an important factor. The question of roll preparation is extremely important from the point of view of meeting the gauge specifications and keeping the weight of the plate within the specified limits.

Our practice is to start out with the rolls perfectly straight at the beginning of the week, and wide plates are scheduled to be rolled when the mill is in this full

condition. As the roll wears in the center, narrow plates are scheduled in the mill, until finally the wear on the rolls is causing a sufficient difference in gauge that the rolls must be changed. Roll changes are determined by the wear on the rolls, which in turn may be a result of roll quality or the type of plates being rolled in the mill.

In setting up a new mill, such as after the week-end shutdown, it is quite important that the rolls be heated gradually, particularly in cold weather, and this is done by scheduling medium width and length plates to be rolled. It might even be advisable to slow down the production rate until the rolls have attained a uniform temperature. With ingots being rolled at temperatures of 2300 F, approximately, it is quite obvious that the rolls would become overheated and water cooling is used to maintain the rolls at a reasonably constant temperature.

INGOT PROVISION

One of the most important factors in the operation of all steel plate mills is the yield of good plate obtained from the original ingot. With the variation in the size of the mills in our plant, that is, from the 48 in. universal mill and the 84 in. plate mill to the world's largest plate mill, 206 in. wide, we are called upon to roll ingots weighing from 1000 lb to 110,000 lb. Without a slabbing mill, we also have to schedule ingots to be made at varying heights in any mold size. For example, ingots with a cross sectional dimension of 54 in. x 23 in. may be poured to a height of 60 in. at one time, and the next time to 70 in. By the over-lapping of ingot weights that can be obtained from two or more mold sizes and the variation of ingot heights that can be poured, a satisfactory system has been worked out to obtain a maximum yield for any type plate.

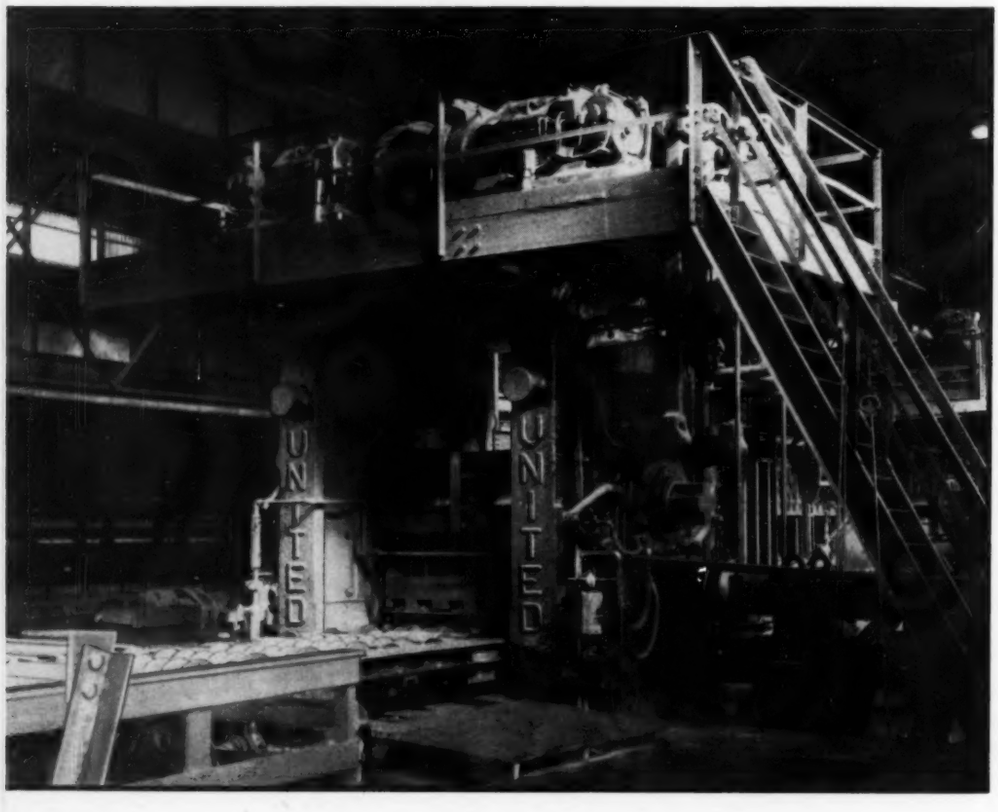
There are two factors that govern the selection of ingot sizes for a specific plate, namely the ratio of ingot to plate thickness and the ratio of ingot width to plate width. It is our practice to use an ingot-to-plate thickness ratio of at least 12 to 1 in order to permit the scale to be removed from the surface of the plate. In the second case, that is, the ratio of ingot width to width of plate, we prefer to use ingots approximately one-third the width of the plate to be rolled and with this practice the side over-roll is kept at a minimum.

YIELDS

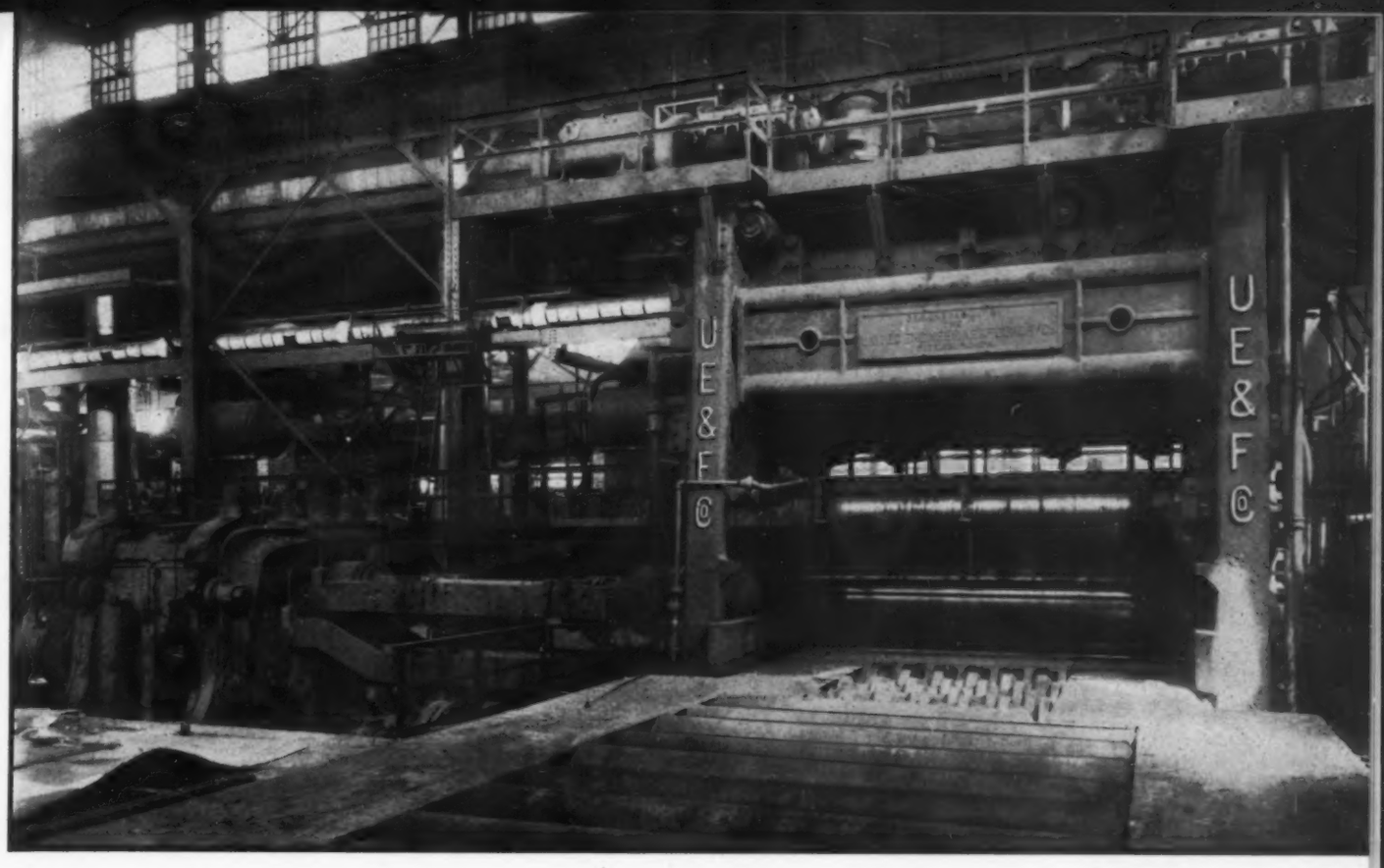
Again with our variety of mills we find that the yield from ingot to plate varies with the type of plate being rolled. With the practice we have established in rolling plates of normal gauge, say up to 1 in. thick, the following figures show average yield practice:

Rimmed carbon steel	Scale loss per cent	Side scrap per cent	Top and bottom scrap per cent	Yield per cent
Plates up to 72 in. wide	2	3	15	80
Plates 100 in. wide	2	5	15	78
Wide and medium gauge plates	3	5	20	72

In the universal mill where there is no side scrap the yield runs as high as 78 to 85 per cent. On hot topped killed steel the yield from the ingot below the hot top to plate is 68 per cent. Hot topped carbon steel and



This 23 in. and 40 in. x 84 in. four-high reversing unit is the finishing stand of a two-stand tandem mill. It is driven by a 1600 hp motor.



This 34 in. and 50 in. x 206 in. reversing four-high plate mill, driven by a steam engine, was built in 1918 and is said to be the widest plate mill in the world. It can roll direct although usual operation calls for breakdowns coming from a 140 in. mill.

alloy steels are generally rolled into wide and thick plates, which explains this slightly lower yield than is generally obtained on rimmed steel.

The outstanding mill we have in our plant is the world's largest plate mill, 206 in. wide, and here it might be well to discuss the actual rolling process used in this mill. Let us assume that we have an ingot of killed steel 71 in. x 70 in. x 23 in., weighing 30,000 lb and we wish to roll this out to a plate 615 in. x 120 in. x 1 in., weighing 21,000 lb.

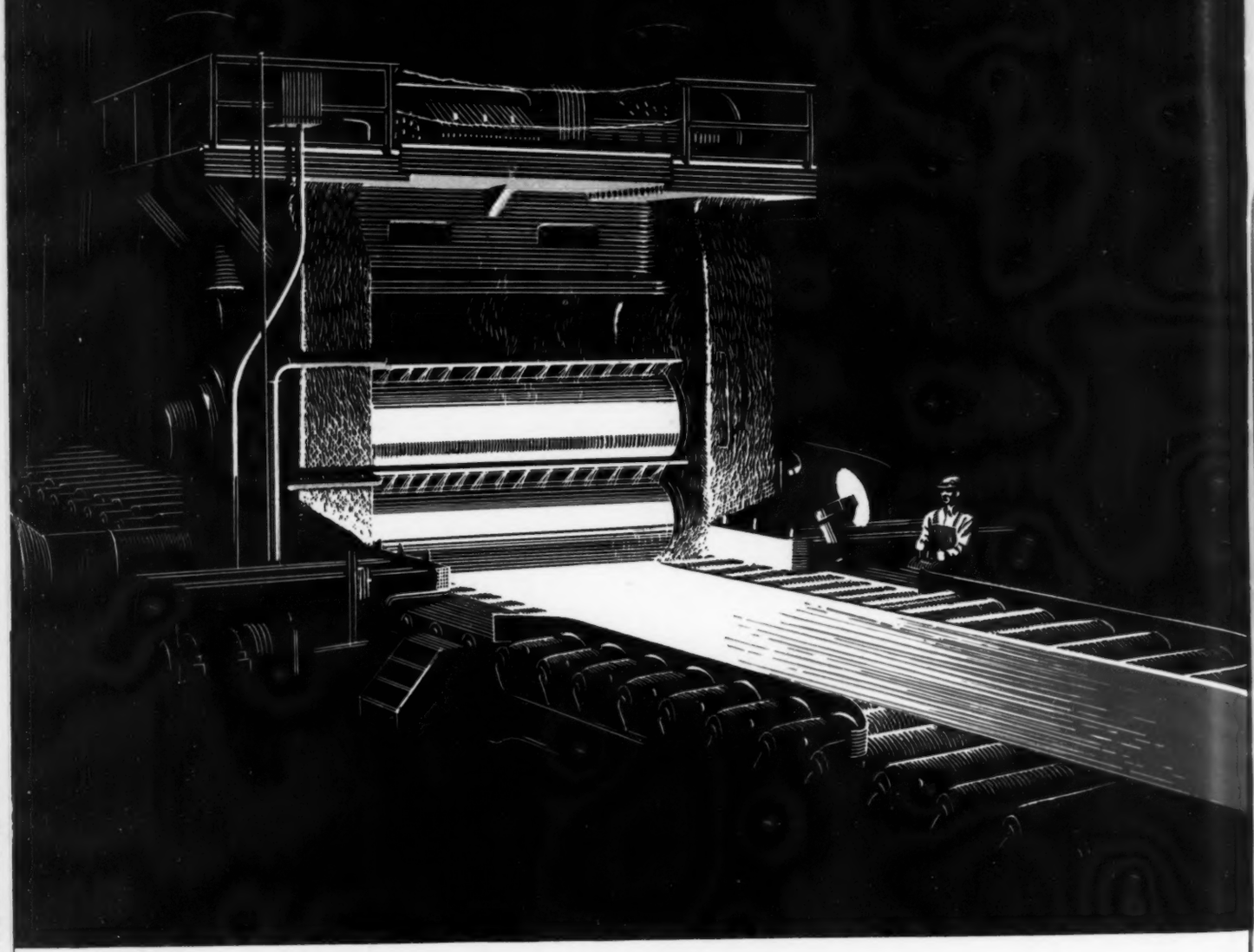
Since all our molds are big-end-down type, the ingot is placed in the mill so that the top end of the ingot is the first part to enter the mill, with a reduction on each pass of 1 in. until the ingot has reached a thickness approximately two-thirds of the original thickness of the ingot — that is, in this case, 15 in. The normal practice is not to exceed a 20 per cent reduction on any one pass in the mill. It is always good practice to roll the ingot down as far as possible in this initial stage in order to avoid excess over-rolling when rolling for width. The ingot is then turned around 90 degrees and by a series of passes the width of the ingot is extended to obtain the plate width desired. The pattern width required on this plate is 120 in. but the roller must take into consideration the side scrap and, therefore, set his rule for 132 in. Once the required width has been obtained the ingot, which is now a slab, is turned back to the original rolling position and rolled to gauge. With the width already established, once the roller has the plate to the desired gauge, the desired length is automatically obtained, since with two known factors the third is a function of the weight of the ingot. To get the required gauge in a hot rolled plate is not the simple matter it first seems and the roller must take into consideration the condition of the mill, the previously drafting of the plate, the width of the plate being rolled and the finishing temperature. You would imagine that, with a gauge dial on the mill, rolling plates to gauge would be a relatively simple matter but take the case of a plate being rolled 100 in. wide and ½ in. thick and another plate 140 in. wide and ½ in. thick. It is assumed, of course, that both plates have finished under similar conditions, that is, the conditions of the mill, draft, and finishing temperature are constant. In the first case, the dial would show a gauge reading of .500 in., while in the second case, to obtain the same gauge it would be necessary to have a dial reading of less than .480 in. This phenomenon is chiefly found in wide mills.

DESCALING

While this ingot has been described as being rolled in one mill, it is our general practice to break down ingots on the 140 in. mill and by means of a transfer carriage the reduced ingot is transferred to the adjacent 206 in. mill. In using these two mills in this fashion a fluted

(*Please turn to page PM 71*)

Drive problem solved



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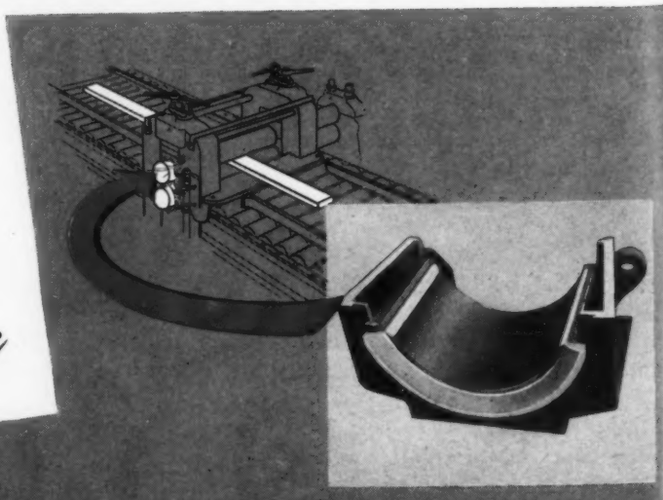
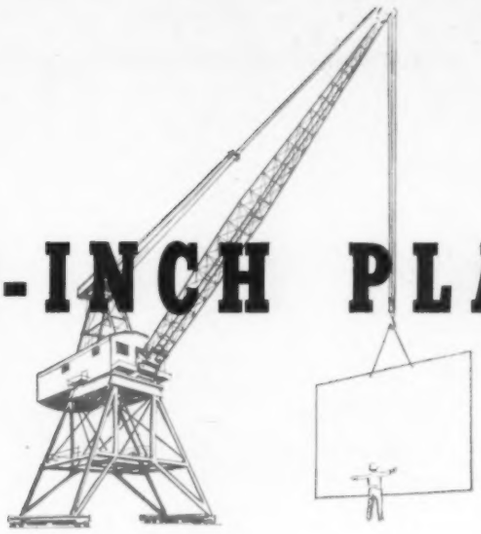


ed FOR 160-INCH PLATE MILL



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To meet America's vast wartime requirements for plate, a new 160″ plate mill was recently placed in operation. Only two mills of such size had previously been built in the U. S. Both were over 20 years old. Thus steel mill engineers faced a whole new set of problems in designing a modern mill of this size.

Key problem to be solved was—what type of drive should be used for the huge reversing stand? Westinghouse industry engineers were called in to study this problem with the steel mill engineers. A single reversing motor would require an extremely large set of pinions. Construction of a single shaft motor of sufficient capacity involved serious engineering problems.

Twin-motor drive was suggested. But such drives had been used only on blooming and slabbing mills for rolling thick, rough sections. Could they be perfectly synchronized to handle the exacting requirements of rolling finished plate?

A practical test was made. Actual plates were rolled on one of the existing twin-motor driven slabbing mills. Results were satisfactory to the steel engineers. Further tests on a 120″ reversing plate mill furnished data for calculating the load on the proposed mill.

Now plate is actually being rolled at high speed from this new mill. Gear maintenance is eliminated, pinion markings on the finished plate avoided—through this practical new application of twin-motor drive.

Here is a typical example of the way Westinghouse engineers are at work today, searching out solutions for steel industry problems. These men are available to help on *your* problems. Just phone your nearest Westinghouse office. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pennsylvania.

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OBSERVATIONS ON

Plate Mill Rolls

by Louis Moses, SUPERINTENDENT
RAIL MILLS AND ROLLS DEPARTMENT
BETHLEHEM STEEL COMPANY
SPARROWS POINT, MARYLAND

▲ A STUDY of roll spallage, based on the initial eight years' operation of a 110-in. three-high plate mill, showed that nine spalled top or bottom rolls had to be scrapped over this period. During these years no plates thinner than the accepted minimum gauges had been rolled on the mill.

In the eight-year period immediately following, thirty-seven top or bottom rolls were scrapped for this same reason. During this time plates were rolled to gauges lighter than the accepted minimum, with roll spallage proportional to the increased tonnage and the greater widths of the product.

Aside from any defects traceable to the foundry, spallage is merely a break-down of the surface metal under heavy loads, imposed and concentrated on a small area of roll surface. Confronted with such a series of operational difficulties, further study or search for the mechanics of these failures would have been considered of little value, except for the possibility of a solution through the use of currently available roll materials. Accordingly, a study of collected data and observations was undertaken, in the hope that some of the findings might point to a solution of the spallage problem. The subject, so far as known, has not heretofore been treated in this manner and the conclusions drawn may be debatable in some of the details.

Spallage from mill causes is primarily due to cold ends and doubled over fish tails, particularly when the plate approaches or has reached the finishing passes. Such ends and fish tails are more prevalent during light gauge rolling than with plate of more normal gauges. This is due to the requirement of rolling light plate in the shortest possible elapsed time and to its light weight on the table rollers creating difficulty with manipulation.

It is well known that the roll pressure required for the deformation of steel rises sharply as the temperature of the material drops. With cold ends and doubled-over fish tails the load on the rolls resulting from either cause, or from a combination of the two, can easily be imagined. Although chilled iron is anything but malleable or shock resistant, it has frequently been found capable of transmitting such impingements through the chill and into the underlying mottled iron without immediately showing a cracked surface. Figure 1 gives an example of delayed spalling of a roll surface in which a detailed rupture has occurred at the point marked A.

Large bruised areas were noted on apparently undamaged rolls taken from the mill on a routine roll change. No cracking could be seen until the first dressing cut was taken in grinder or lathe, when hairline

Presented before A. I. S. E. Philadelphia District Section Meeting, January 8, 1944

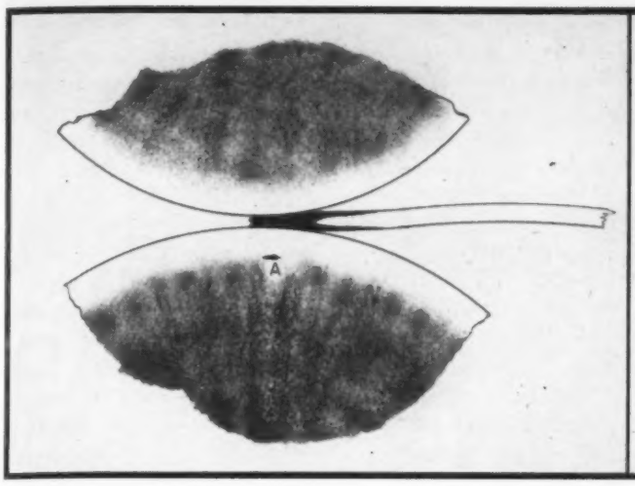

Figure 1 — Example of delayed spalling caused by an internal rupture at point A.

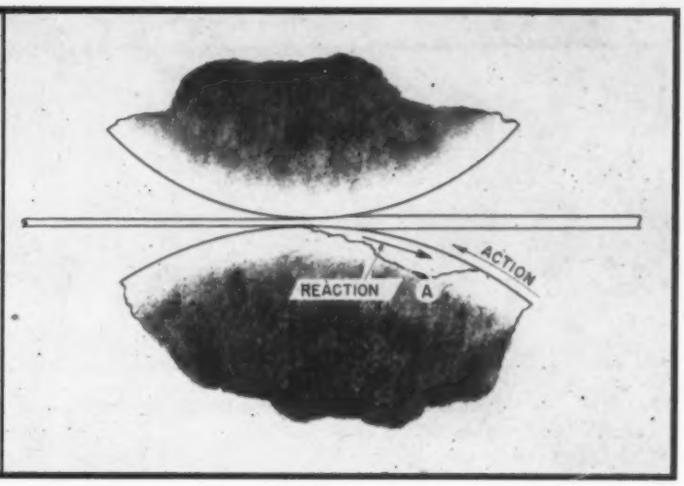

Figure 2 — Subsequent rolling after an internal rupture at A tends to cause external spalls or cracks.

cracks appeared at the borders of the bruise. When the bruised area was struck with a hand hammer the sound emitted was dead and hollow, in contrast to the characteristic ring associated with sound metal. When a tool cut was taken, the bruised area peeled away, generally leaving the exposed fracture bright and unoxidized.

Spallage never penetrated into the grey-iron core of the roll, but always terminated in the zone of mottled iron. It was noticed that spallage seldom occurred with rolls which were so nearly worn out that specks of mottled iron could be seen. However, as such a surface imparts a rough and undesirable finish to a rolled plate, this did not offer a practical solution to the difficulty.

Occasionally small shallow spalls could be successfully cut away. As these appeared in the shop the locations would be carefully noted before dressing the roll surface down to clear metal. Of twelve middle rolls for which such a condition had been reliably recorded, only five were subsequently found to give satisfactory service. The remaining seven immediately let go at the original spalled location, proving that a deep seated fracture existed, even though its growth had not extended to a point where the action of the tool would break away the bruised metal.

Figure 2 illustrates the rolling of a plate after the damage to point A had occurred. The driving torque applied through the roll face is opposed by the braking effect of the plate being rolled. As a result the rim of the roll has a tendency to crawl around the core.

When point A arrives at the relative position shown, some of the direct acting force is tangentially resisted by the part of the roll face situated ahead of point A and having the detail as its base. Growth and extension proceeds from A to the outer surface. This continues until rupture takes place, when the piece either breaks away or a crack appears. Fracture may occur instantaneously or, as noted, may be retarded, depending on the intensity of the blow imposed.

The theory of spallage growth around the roll's circumference is not entirely applicable to friction-driven middle rolls. Although no similar tendency of surface crawl is present, it is nevertheless currently believed that some such influence exists.

Figure 3 shows representative descriptions of spallage as condensed from the roll record cards.

The long dimensions always lay around the circumference of the roll. It could be argued that a very long, cold edge could cause such a spall by crushing action alone. It was observed, however, that these spalls were not accompanied by similar damage to the opposing roll face. If they were due to crushing action into the chilled iron, it is reasonable to assume that both rolls would suffer the same amount of damage.

Experiments were made with the different grades of roll materials then available, the control consisting of plain and molybdenum chilled iron at 65 hardness and chill depth at $\frac{7}{8}$ in. The rolls were varied from a mild 55 to a hard 70 and the chill depths ranged from a shallow $\frac{1}{2}$ in. to a deep $1\frac{1}{4}$ in. The softer grades were easily marred and marked and the various chilling depths offered no distinction.

One aim is to have the greatest possible depth of clear chill in a roll, in order to attain the maximum roll life, but this depth is regulated by the composition of

Figure 3 — Examples of spalling, taken from roll record cards.

ROLL	DESCRIPTION	ROLL	DESCRIPTION
B	ALL AROUND		
B	12" X 24"		
B	12" SQUARE	MIDDLE	3" DIAMETER
T	8" X 12"	"	2 SPALLS AT LATHE
B	TWO PLACES	"	3" DIAMETER
T	8" WIDE - VERY LONG	"	2 PLACES - 11" WIDE - LONG
B	6" DIAMETER	"	14" DIAMETER
B	9" "	"	6" "
T	12" WIDE - 1/3 AROUND	"	2 - 12" DIAMETER
B	1/3 AROUND	"	6" WIDE - 1/3 AROUND
B	SMALL	"	12" DIAMETER
B	12" X 36"	"	10" X 20"
T	10" X 24"	"	5" DIAMETER
B	12" X 18"	"	3" "
B	18" DIAMETER	"	3" WIDE 1/2 AROUND
T	SMALL - GRAIN	"	10" X 20"
T	1 - 1/2"	"	6" DIAMETER
B	12" X 18"	"	12 "
B	4 SMALL AROUND BODY	"	LARGE
T	BRUISED		
B	8" ACROSS		
T	3" DIAMETER		

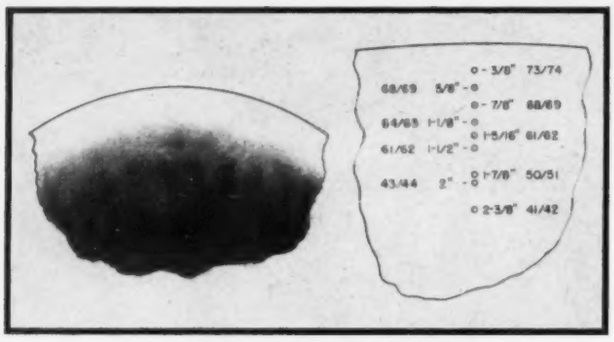

Figure 4 — Representative hardness readings at various measured depths in an alloy iron roll.

the liquid metal in the pouring ladle. Very deep chilling is possible, but in the process, the structural properties of the casting are adversely affected. A chilled roll so made was therefore not a practical solution, even though a deep bridge of hard surface metal through which damaging forces must penetrate was indicated.

The advent of an alloy material for use in rolls of plate mill dimensions and weights coincided with impending preparations for war, when maximum production of plate was demanded from the mill. The production of light gauge plate was reduced, but not wholly eliminated, because of the greater demand for plate of normal gauge.

This material belongs to the alloy-iron, intermediate-chill, or hard grain types, in which the graphite is so finely dispersed that it is visible under magnification only. It produces a splendid finish to a rolled plate. Representative hardness readings at various measured depths are reproduced from furnished data on Figure 4. Impacts tending to produce spallage must travel through a much deeper bridge of hard material before they reach an open mottled-iron structure comparable with that of chilled iron.

Some light gauge plate has been rolled during the past two and a half years, but not to the same extent as during the period when spallage made necessary the scrapping of thirty-seven rolls. However, a great deal of faith is placed in the ability of a heavy layer of hard metal to decrease spallage incidence, should these alloy rolls be exposed to such a condition.

One problem always accompanies exhibitions of comparative roll performance. In making deductions it is necessary to consider a possible selection of figures aimed at a desired end, by omission of descriptive notes on the conditions under which respective rolls were run. This is particularly true when performances over two or more extended periods are compared. Under otherwise equal conditions the last period should exhibit improved performance by reason of advanced mill practice, regardless of the type of rolls used. Sometimes one condition complements the other, making it difficult to decide upon the real deciding factor. The state of the order book during periods of depressed business must be taken into account, because the most advantageous mill routines are interrupted at such times. Discounts must always be made in favor of rolls scrapped in the less fortunate periods when exposure to damage is greatest.

Figure 5 shows the major factors involved in this connection. A sharply defined division of roll materials is not possible between the six-year, the two-year, and the six-month periods. The roll stock of any mill, excluding new ones, always includes rolls ranging from new to almost worn out. For this reason some of the rolls selected in compiling the performance figures actually had produced some, or even a large part, of their life tonnage during preceding periods.

The outstanding and significant feature of the alloy roll is, that thus far none has spalled. There is no discounting whatever required in the six-month period when chilled-iron bottoms were paired with alloy tops, simultaneously producing the same product, plate for plate. Three chilled-iron rolls were scrapped on account of spallage, with the alloy rolls undamaged.

Comparisons in terms of tons rolled per one-inch reduction in dressing are reliable only on the assumption that accidents will not occur to shorten the indicated life expectancy. Here again some discounting is necessary because the figures shown do not represent equality of light gauge rollings. The relative wear resistance is, nevertheless, highly favorable to the alloy roll, if only because of the complete absence, at any time, of pitting or tail marking. Such marring of the surface requires

EXPOSURE	CONSIDERABLE LIGHT GAUGE PLATE	SMALL TONNAGES OF LIGHT GAUGE PLATE			
PERIOD	SIX YEARS	TWO YEARS WITH ALLOY PREDOMINATING		SIX MONTHS OF COMBINATION	
ROLL MATERIAL	CHILLED IRON	CHILLED IRON	ALLOY	CHILLED IRON BOTTOMS	ALLOY TOPS
NO SPALLED	36	-	-	3	-
AVERAGE TONS PER ROLL * ALL CAUSES OF SCRAPPING	34,537	?	76,700	26,150	50,349

	AVERAGE TONS PER ONE-INCH DIAMETER REDUCTION	AVERAGE TONS PER DRESSING	EXPOSURE
6 YEARS OF CHILL	42,900	6,146	LIGHT GAUGE
2-½ " " ALLOY	89,413	9,615	LIGHT GAUGE LIMITED

Figure 5 — Chart showing history of roll experience with 38 in. x 114 in. top and bottom rolls in a three-high plate mill.

additional dressing, over and above reductions taken to restore the contour. This feature of the alloy roll is also undoubtedly related to the absence of spallage experienced thus far. The non-marring characteristic is of particular value when rolling high quality plate which is later to be pickled.

In nine years of mill operation preceding the earliest period shown in Figure 5, only four body breaks of top and bottom rolls occurred. In two and a half years of trial of alloy rolls an equal number of these broke, that is, four times as many based on the same interval of time. Such failures are almost invariably expansion breaks caused by thermal shock. As sensitive as the chilled-iron roll may be to this failure, the extremely hard alloy rolls appear to be even more so. Each of the four broken alloy rolls was considerably harder than the presently adopted figure of 72 to 75. No roll within the latter hardness range has suffered breakage. The harder rolls produced about ten per cent greater tonnage per one-inch reduction but their total life was drastically shortened by the described breakage.

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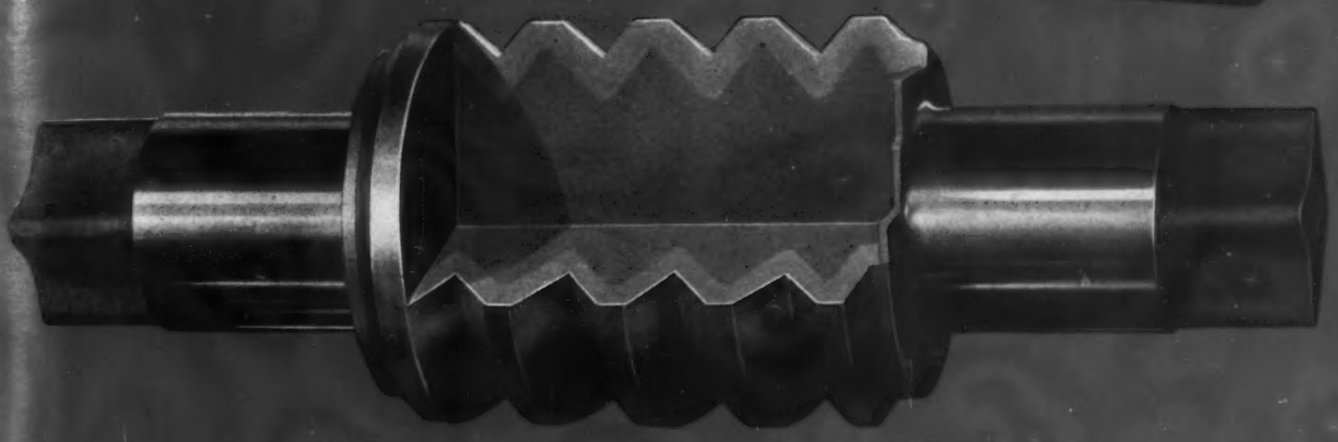

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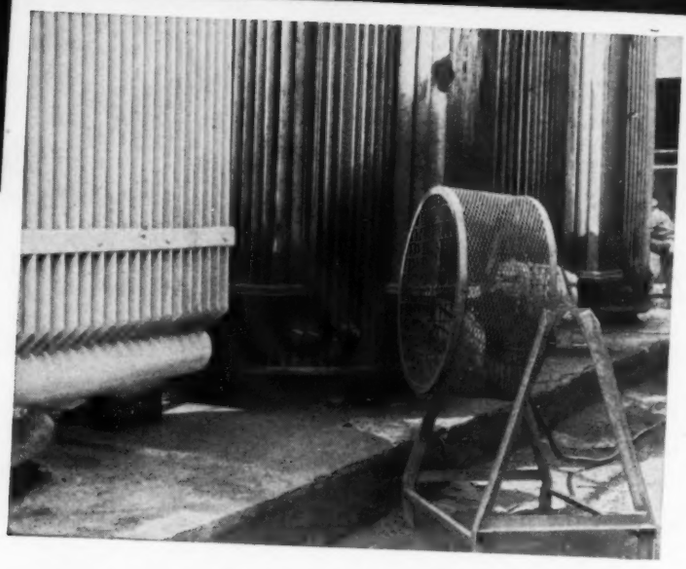

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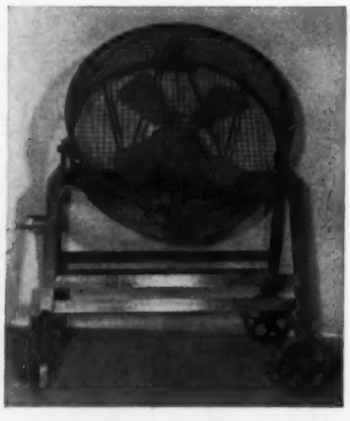

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Plate Mill HEATING FURNACES

by A. J. Fisher
FUEL ENGINEER
BETHLEHEM STEEL COMPANY
SPARROWS POINT, MARYLAND

▲ MOST slab heating furnaces come under one of three classifications: (1) direct-fired with cold air; (2) direct-fired with recuperated preheated air; and (3) direct-fired with regenerated preheated air. Where oil or clean gas fuel of high Btu is used the two first types have been the favorite choice of furnace engineers. This is particularly true for small furnaces, primarily on account of the ease of installation and of operation with automatic combustion controls. Many steel plant operators have looked longingly to the regenerative furnace, hoping that a standard design, easily controlled, would some day be forthcoming. The purpose of this paper is to describe and explain the construction and operating features of a well designed and efficiently controlled regenerative furnace that should rate high in this class. It is ideally suited for heating heavy slabs uniformly without washing, within the 2400 F range.

The particular furnace here described was designed and built at Sparrows Point. Four furnaces of this type were installed for heating hot and cold slabs for the 160 in. plate mill at that plant.

The overall outside measurements of the furnace buckstays are 62 x 15½ ft, the inside dimensions of the hearth area 40 x 10 ft. Considerable space is taken up by the two vertical checkers at each end of the furnace. (Figure 1). A 1 ft layer of chrome ore, rammed in place on 18 in. of first quality Pennsylvania clay brick, makes up the furnace hearth. The front wall is 18 in. thick, up to a point 2 ft 10½ in. from the furnace bottom, where it racks back to 13½ in. It is laid up with chrome brick to two courses above the bottom, to protect it against erosion by scale. Above this point, the wall and door arches are constructed with semi-silica Jersey clay brick, as shown in Figure 2.

The back wall is of the same thickness as the front wall and also has two courses of chrome brick, the remainder being laid with superduty Missouri clay brick (Figure 3).

The bridge walls are racked back from 3 ft 2 in. at the bottom to 13½ in. at the top and are faced with two courses of chrome brick, the remainder being semi-silica Jersey clay brick. They follow the contour of the roof, with an opening 27 in. high between the top of the wall and the roof. The end walls and bulkheads above the vertical regenerators are 13½ in. thick and are made of semi-silica Jersey clay brick.

Slabs are handled in and out of the furnace by overhead charging cranes, through four water-cooled doors. The two outside doors are single, with door jamps on either side, whereas the two middle doors have jambs on the outside only. When the middle doors are up together, a very large access opening is therefore available for handling extra long slabs, or when slabs are

Mr. Fisher describes modern in-and-out furnaces designed and built by Bethlehem. Other heating facilities used in some plate mills are continuous slab heating furnaces (see "The Modern Strip Mill," published by the Association of Iron and Steel Engineers, 1941) and soaking pits (see Iron and Steel Engineer, April 1943).

Presented before A. I. S. E. Philadelphia District Section Meeting, January 8, 1944

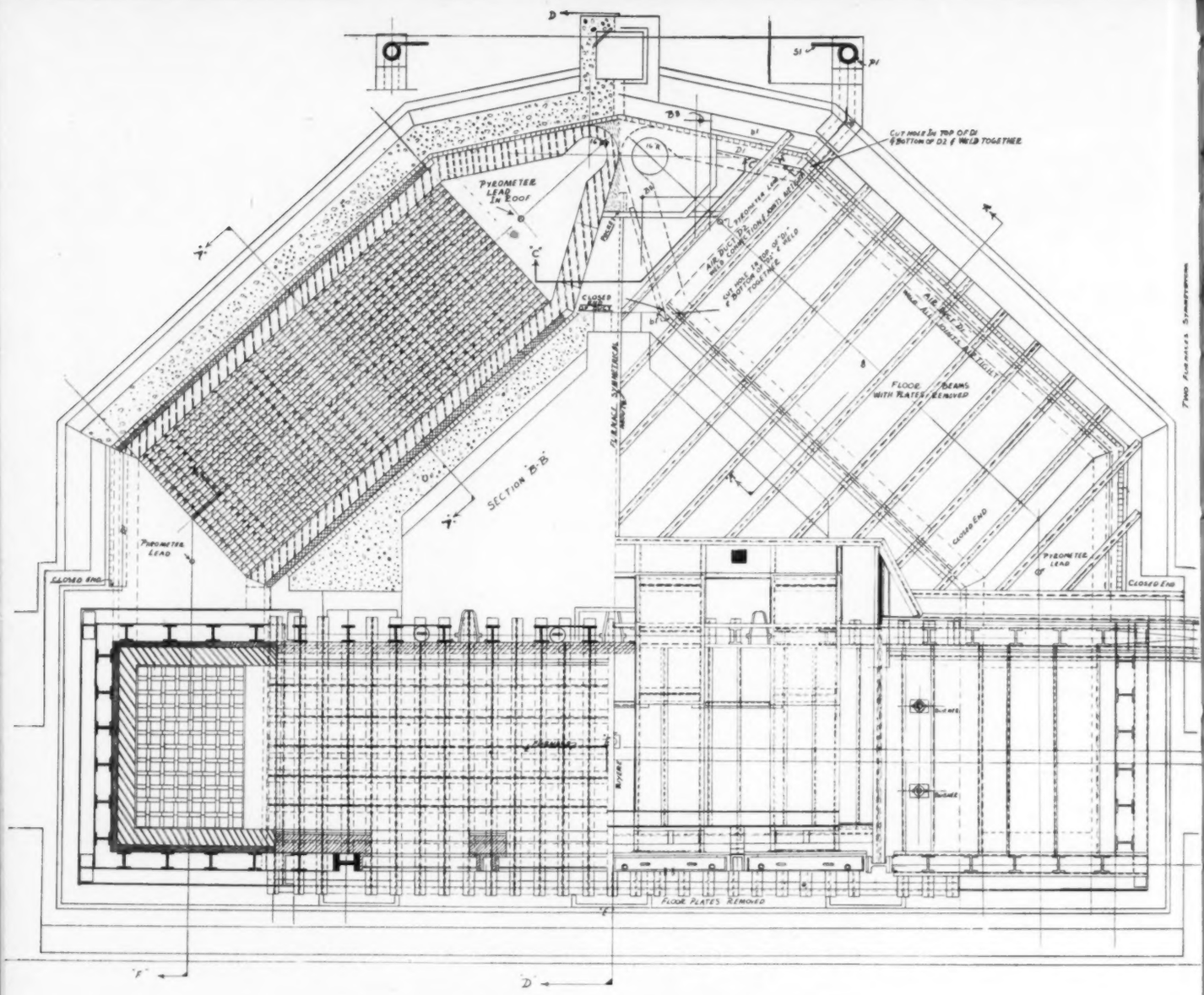
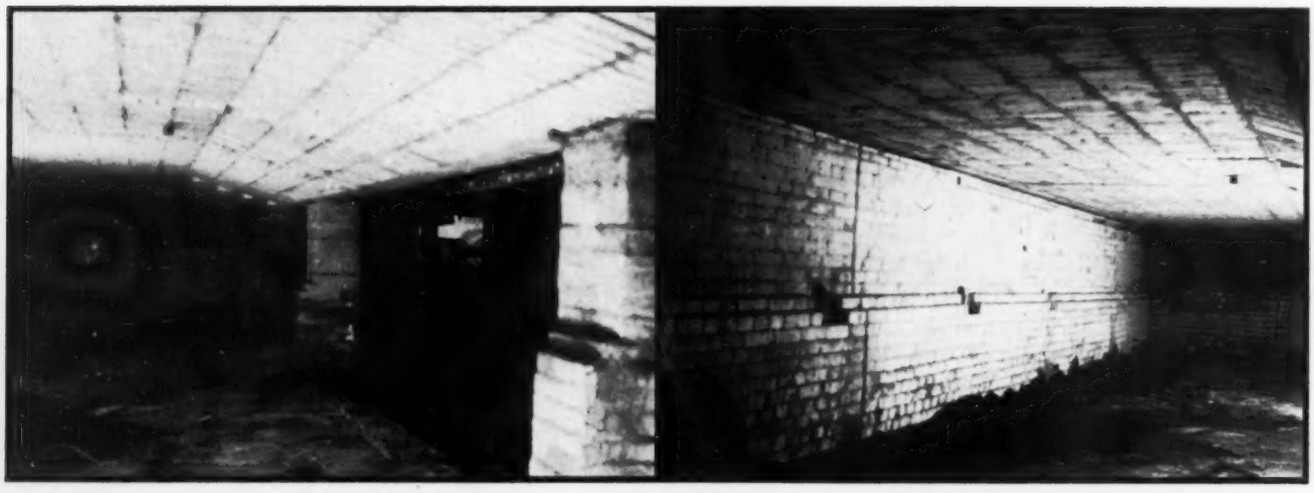


Figure 1 — Plan view of furnace, regenerators and flues.

▲

Figures 2 and 3 — Views within the furnace, showing front wall and back wall respectively.



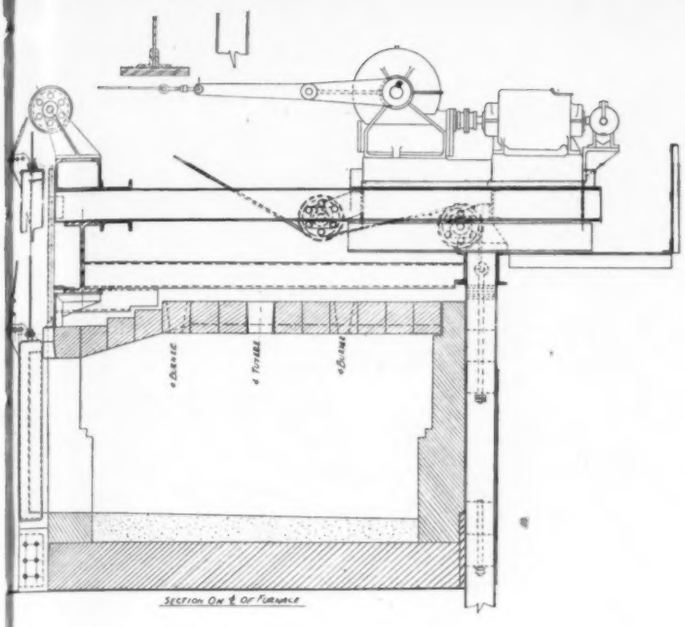


Figure 5 — Cross-section of furnace showing roof sloping downward to front wall.

reheated after a preliminary breakdown rolling on the mill. The doors are of the open-lattice type, water cooled and lined with 4½ in. of first quality clay brick. They are made of a high-strength, corrosion-resistant low-alloy steel which withstands the action of warm saline cooling water very well.

The roof is a flat suspended arch, 9 in. thick and constructed with superduty Missouri clay brick. It is not insulated. The brick have a P. C. E. of 33-34, which represents a fusion point of about 3190 F. At the front wall the roof level is 5 ft above the bottom and it slopes up to 6 ft ¼ in. at a point 4 ft from the top of the front wall, from which point it remains flat to the back wall (Figure 5).

The roof buttresses against an alloy water-cooled lintle over the doors, expanding freely toward the back wall.

Three oil burners are located at each end of the furnace, directly over the bridge walls. To compensate for the water-cooled door front, they are crowded toward the front of the furnace, giving an even heat from front to back wall. The burners are water cooled and do not require any attention as far as cleaning is concerned. They are connected with a central steam-oil mixer, from which oil and steam, in equal amounts, are fed to each burner. Steam for atomization is kept on the deficient side in order to give a black smoky flame of very high carbon content. The steam and oil lines to the mixers have air-operated diaphragm shut-off valves, remotely controlled by means of three-way solenoid valves. Both oil and steam are completely shut off during the dead-end cycle and all other periods when no fuel is required on the furnace (Figures 6 and 7).

REGENERATORS

The regenerators are of the two-pass type with one vertical pass at each end of the furnace, and one horizontal pass leading on an angle directly to a pair of stacks on the centerline of the furnace.

The vertical-pass checkers are of the closed-flue type and are made of first quality Pennsylvania clay with 96 openings, 7½ by 7½ in. square. They have a depth of 11½ ft and a total effective exchange area of 3840 sq ft. Flue gas enters at a velocity of 11 ft per second (Figure 8). The horizontal checkers are of the open type, 26 ft long, made of first quality Pennsylvania clay and have 162 openings, 4½ in. by 6 in. The effective exchange area is 9950 sq ft with the flue gas entering at a velocity of 8 ft per second (Figure 9). The roof over the horizontal checkers is a sprung arch of first quality Pennsylvania clay brick, 9 in. thick.

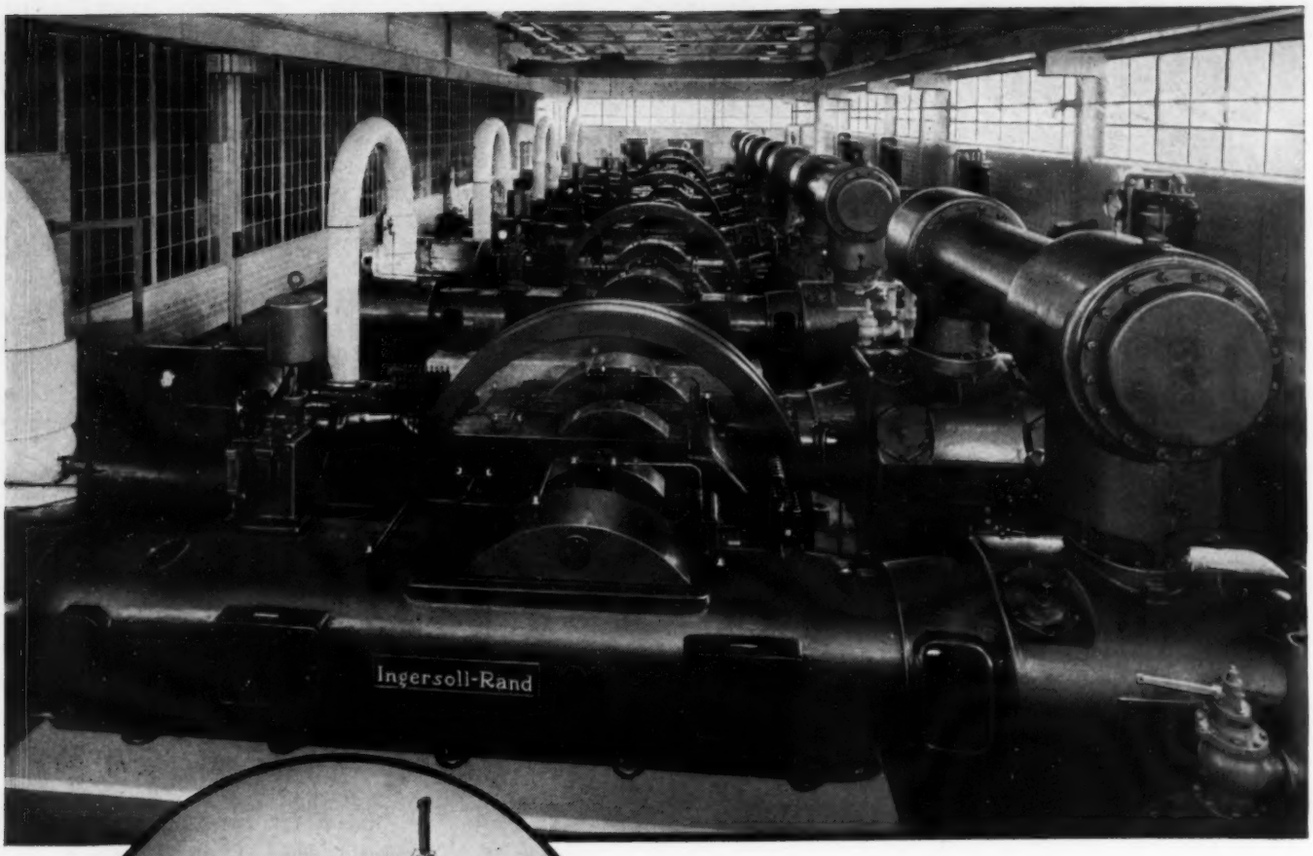
The temperature of the flue gas entering the top of the first pass is 2500 F, at the second pass 1250 F, and at the stack 500 F. The air is preheated to a range between 1800 and 2000 F.

A 4½ in. layer of insulating brick is used as insulation on all regenerator walls, flue walls, end walls, and bulkheads, while the horizontal regenerator roofs are covered with 2½ in. bricks of the same type. On the outside of the insulation the furnace has a complete casing of steel.

Each furnace is equipped with twin stacks operated by a single fan feeding through two separate ducts, one for combustion air and one for induction air. The butterfly and slide valves in the stacks are operated by individual oil cylinders from the control panel. A butterfly valve operated by an oil cylinder with two stops regulates the fan induction air for furnace pressure. The flow of combustion air is controlled by a butterfly valve which is set and locked in a fixed position.

Mechanical reversing time is three seconds and "fuel off" to "fuel on" twelve seconds. The furnace is reversed by time cycle every three minutes.

Figure 4 — Furnace doors are arranged so as to give maximum accessibility to the interior of the furnace.



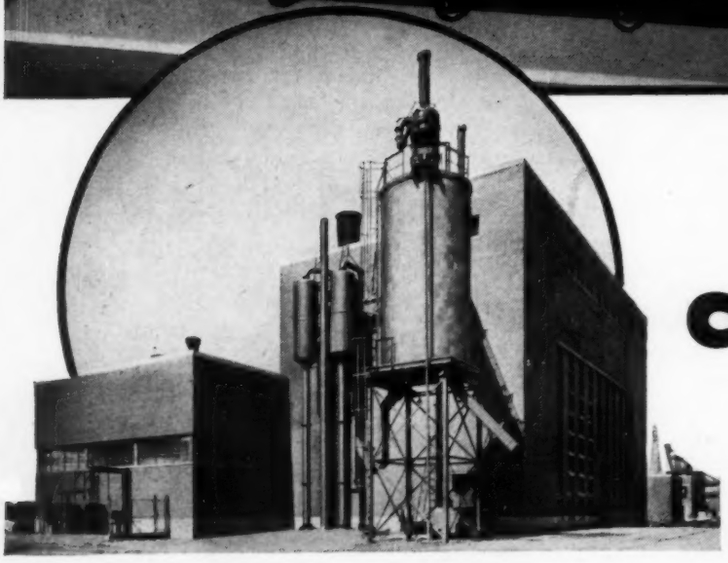


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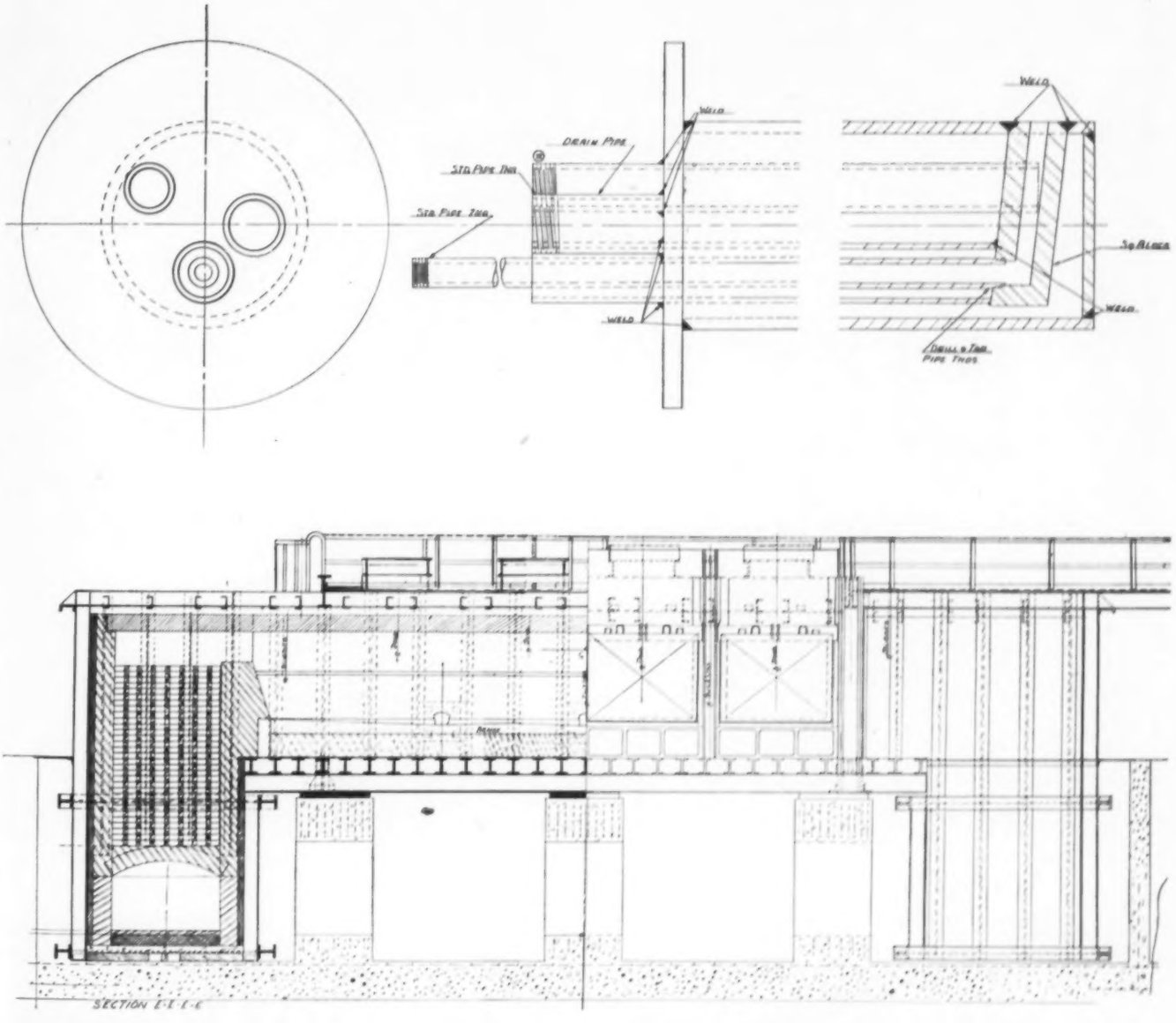
Figure 6 — View toward bridge wall showing oil burners coming down through roof and located toward the front wall.

Figure 7 — Sketch showing construction of oil burner.

Figure 8 — (bottom) Sketch showing side elevation and cross-section of the flame.



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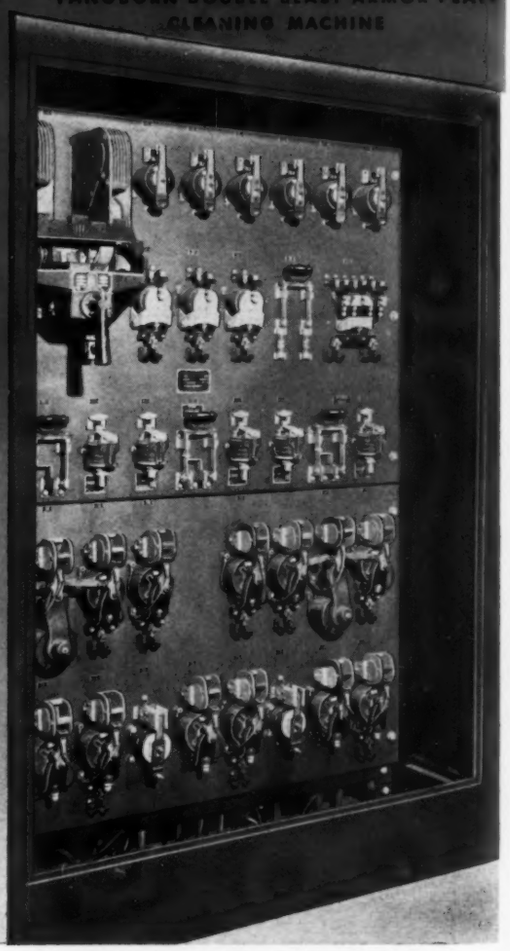

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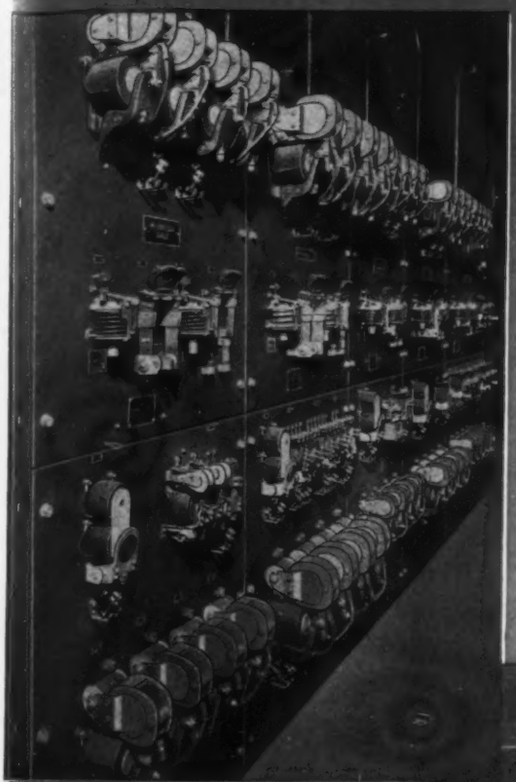

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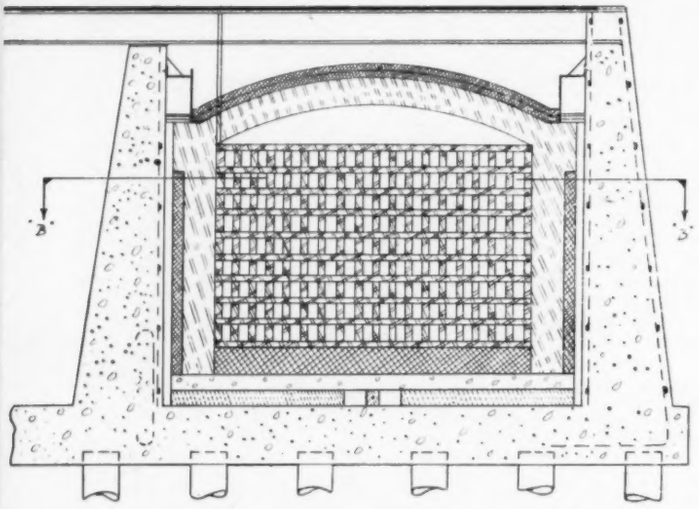

Figure 9 — Section through horizontal checkers in flue leading to stack.

Steam pressure is indicated by a pressure gauge and oil flow by an area-type flow meter, while furnace pressure is recorded on a circular chart. Flue gas temperatures, taken between the first and second pass and at the exit of the second pass checker chambers are recorded on a strip chart.

The principal control of the furnace is a strip-chart potentiometer connected to a platinum-rhodium thermocouple. This instrument is equipped with electrical contacts set to cut the fuel off and damper the furnace at 2550 F, and to turn the fuel on and open the forced draft and furnace exhaust valves at 2475 F. During the heating period, the oil remains on until the desired temperature is reached, after which a series of soaking and heating periods occurs until drawing time. The steel is heated very uniformly and without danger of burning the edges, which would surely occur with a full floating type of control.

The prime advantage in using a fixed fuel rate is an even temperature distribution in the furnace. Most furnaces can easily be balanced for even heat liberation throughout the hearth for the maximum heat input flow. However, if the fuel rate is reduced according to temperature, unbalanced heating usually occurs. By use of a fixed fuel input, together with dampering, this condition is avoided.

The feature of principal interest in any furnace is its performance. Quality of heating, time, fuel rates, and maintenance are the prime considerations.

As previously stated, the quality of heating is very good on these furnaces. The slabs are heated uniformly and can be held in the 2400 F range without washing. This temperature range, together with the highly oxidizing atmospheres encountered during automatic dampering, results in a thick, uniform coat of scale on the slabs, which breaks off easily on the first or second pass through the mill. The advantage of a thick scale which peels freely and leaves a clean surface is readily seen, inasmuch as surface defects are closely watched during inspection.

The furnace has an average heating rate of from 10 to 15 tons per hour, with 6 in. slabs charged at 1500 F, and roughly half this rate when cold slabs are charged.

The average yearly over-all fuel rate for all grades of steel, both hot and cold, is 1,586,000 Btu per ton of steel heated. Performance on single heats of hot steel will run 1,000,000 to 1,200,000 Btu per ton, and roughly twice this amount for cold steel.

Maintenance is very low, inasmuch as the furnace is automatically controlled from temperature, and therefore, never reaches the fusion point of the refractories. Scale accumulations on the bottom are removed when the mill is down, by use of large, specially designed scrapers attached to the charging crane. The furnace maintenance from all sources is approximately $0.20 per ton of steel heated.

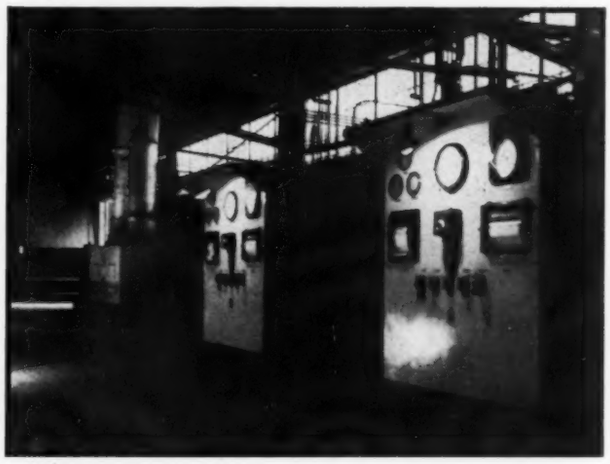

Figure 10 — Each furnace has its own separate panel board carrying instruments and controls.

▲

Figure 11 — Furnaces are charged and drawn by an overhead charging crane.

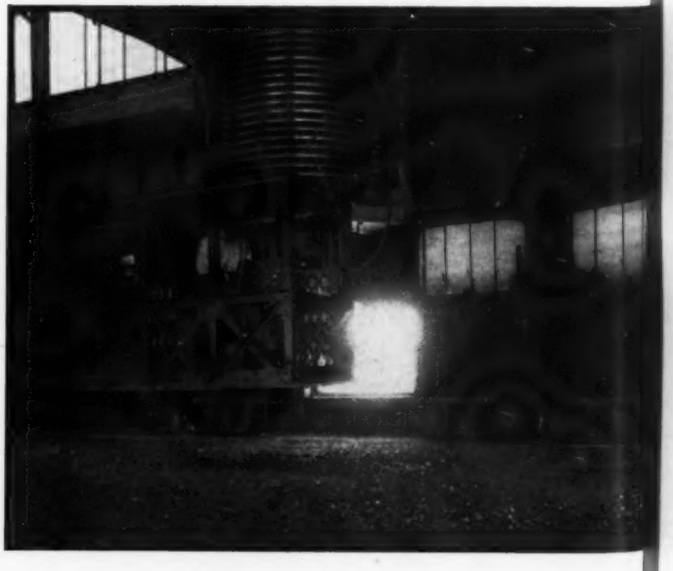

Plate Rolling Practice

(*Continued from page PM 51*)

middle roll is used in the 140 in., three-high mill, acting as a scale breaker. The fluted roll breaks the scale on the top and bottom of the ingot and steam, water sprays and salt are used during the remainder of the rolling operation to remove scale. The fluted middle roll is also being used in the break-down stands of our other plate mills. The fluted roll method is extremely efficient because the scale is readily removed from both the top and bottom surfaces. In the rolling of some special alloy steels, particularly nickel steel, it is difficult to remove the scale by the normal method of water sprays and steam, but by using the fluted roll an efficient descaling job can be accomplished. While the methods for descaling have been described here, there is another important factor affecting the removal of scale, that is, accurately controlled heating pits and furnaces.

In the rolling of alloy steels, such as the stainless group, the reduction per pass is very much less than for carbon steel. We have found it advisable to keep water off the rolls until the width of the plate has been obtained. Stainless steels are tough even at a high temperature and the water is taken off the rolls with the object of holding the heat in the slab as long as possible. In most cases it is necessary to take at least two heating and rolling operations before obtaining the finished plate. In the rolling of clad steels, such as nickel clad steel, the percentage of reduction per pass is slightly less than for carbon steel.

The amount of cross rolling done on an ingot is generally reflected in the results obtained on transverse tensile tests. For example, the elongation is much higher on a cross rolled plate than a plate rolled only in one direction. This means that cross rolling improves the ductility across the width of the plate.

The finishing temperature of a rolled plate is generally relative to the thickness. As the thickness increases, so does the finishing temperature. If two ingots are taken from the same heat of steel, one rolled to a thick plate and the other one rolled to a thin plate, the tensile strength will be lower on the thick plate. In the case of the thick plate the actual grain size will be much larger than on the thin plate, which is the result of the difference in the finishing temperature of the two plates.

The plate, on leaving the mill, is taken direct to a roll straightening machine where the plate is flattened to meet commercial requirements.

In the larger mills where plates are finished at temperatures of about 1600 F, this temperature is sufficient to get a good flattening operation. In the smaller mills, such as our 84 in. mill, where lighter gauge plates are rolled, the finishing temperature of the steel is generally below 1600 F and it is necessary to pass them from the mills straight through a continuous annealing furnace to remove rolling strains and to raise the temperature of the plates to permit a good flattening operation.

DISCUSSION

PRESENTED BY

L. F. COFFIN, Superintendent Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

W. P. GERHART, Metallurgical Engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania

A. E. MURTON, Manager Roll Department, Continental Foundry and Machine Company, East Chicago, Indiana

H. S. HALL, Fuel Engineer, Lukens Steel Company, Coatesville, Pennsylvania

C. R. HAND, Lubrication Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

H. L. WATSON, JR., Assistant Superintendent, Special Products, The Midvale Company, Philadelphia, Pennsylvania

M. J. CONWAY, Special Engineer, Lukens Steel Company, Coatesville, Pennsylvania

W. H. JOHNSON, Mechanical Engineer, Worth Steel Company, Claymont, Delaware

LOUIS BUNTING, Superintendent of Plate Mills, Lukens Steel Company, Coatesville, Pennsylvania

A. J. FISHER, Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland

D. BRUCE JOHNSTON, Lukens Steel Company, Coatesville, Pennsylvania

T. T. WATSON, Director of Research, Lukens Steel Company, Coatesville, Pennsylvania

L. F. Coffin: It is very significant that we have a plate mill symposium, because all operators of jobbing plate mills realize that after the war, their rolling practice and their quality and ability to get maximum yield with reduced cost is going to be a determining factor in the struggle to keep too many orders from going to the large continuous plate mills, converted from strip mills. Plate mill operators should collaborate in meetings of this kind oftener.

There is one phase of plate mill practice that is very important: the question of bearings. Roll life and breakage and uniformity of gauge are partly dependent upon bearing practice. This is extremely well exemplified in the modern continuous hot strip mill. Possibly in the not too distant future we will have a gauge that will allow the roller to gauge the center of the plate as well as the edge.

It is possible that many of the older type heating furnaces may be remodeled and modernized with automatic or semi-automatic control without too great expense.

W. P. Gerhart: I like the furnace design as covered by Mr. Fisher's remarks. However, in heating large ingots or slabs weighing in excess of 20,000 lb, particularly over 18 in. in thickness, or of high sulphur steels that are usually heated to 2450 F, I believe a good set of soaking pits, located close to the rolling mills, will work to a great advantage in time required in heating.

With respect to the excellent talk by Messrs. Bunting and Watson, I could say a great deal about Lukens' practice; however I will limit my remarks to the fact that, with their new mill as described, they are no doubt paving the way for similar mills by the industry in the near future. There is little doubt but that the single stand mill, where roughing and finishing are done on the same rolls, will some day pass out of the picture. Also, I doubt whether the continuous mills are flexible enough to satisfy normal production requirements of quality plates. I believe the so-called strip mills will rely mostly on sheets after the war.

Finally, Mr. Moses has done a grand job on rolls and their design, not overlooking their composition, which has been a real contribution to our company and to the producer of rolls.

Since rolls are a most important part of mills rolling flat products, regardless of type, I am of the opinion that the old three-high mill converted to a breakdown mill, followed by a four-high, is the real answer to the plate mill problem.

A. E. Murton: I was rather impressed with the fact, in the discussion of the Lukens mills and also in Mr. Moses' discussion, that both speakers emphasized certain features of rolls. For instance, their sensitivity to thermal changes and the seeming marked ability of cast iron rolls to spall. As roll makers, we recognize the fact that it is a serious problem, especially as regards the future of the jobbing plate business and also in the strip business.

There is one thing that appeals to me very much. That is the fact that we are getting a start towards some intelligent, well-thought-out analysis as to what the problems are that cause spalling of rolls. There has been for a good many years a tendency for the mill man to throw up his hands and say, "The darned thing has spalled — what are you going to do about it?" Well, that doesn't profit anyone. So it is gratifying that Mr. Moses has tried to analyze this thing and has done a very good job, and I hope he is pointing the way for more men to do the same thing, because the average roll maker going into the steel plant is rather in the position of a doctor who walks into your house when you are sick. The only way he can make an attempt to cure you is to find out what is wrong. And we can only find out what is wrong by getting an intelligent analysis of the picture as it exists. I might say that the discussion of spalled rolls follows very closely along the lines that we have been thinking.

In the first place, the definite chill type roll, due to the bridge effect or the rather sharp line of demarcation between the clear chill and the mottled surface — and that goes for the molybdenum or various alloys — has a tendency to make a line of demarcation, which caused the spalling, and the alloy grain type, where you get deeper penetration, is definitely an improvement, provided you do not try to reach maximum hardness, where you lose what little malleability there is in cast iron.

H. S. Hall: I have a question I would like to ask Mr. Fisher. What is the maximum size of ingot or slab which is charged in the furnaces?

C. R. Hand: Composition bearings may be expected to give good service in plate mills when the following conditions are maintained:

First: Suitable manufactured material, as proven for that particular service, must be used. There are several possible combinations of bearing construction and various additives have been used.

Second: Composition shells must be closely fitted to mill chucks and firmly held in their proper relative settings. Any slipping will soon rupture the parts next to the keepers and failure of the entire bearing will result.

Third: Windows must be kept up. Sloppy fits between chucks and windows will cause severe hammering on the composition material resulting in a pulverized bearing. All back lash must be eliminated.

Fourth: Tight fitting scale guards must be held in place at all times. Scale can ruin a bearing and roll neck in ten minutes.

Fifth: Roll necks must be smooth. Polishing is not necessary. A brown coating on a neck is an indication that the neck will run on composition bearings. Pitted necks will not run. Light score lines, concentric with the neck, will run. However, bearings wear faster.

Sixth: Sufficient cool water (under 100 F) must be applied to carry frictional heat away from the neck as fast as it comes out of contact with the bearing. Volume is important; pressure is not. On bottom bearings, pressure should be used so as to wash scale away from the sides of the bearing next to the roll neck. Salt water cannot be used. High percentages of acids or alkalies in cooling water soon ruin the neck surface and help raise roll turning imperfections. (Small particles of metal pushed over by roll lathe tools rise up from expansion brought about by the chemical attack.)

Seventh: Roll necks must be protected from rusting when mill is shut down. Black oil is sufficient protection and is either sprayed on or swabbed on. Failure to prevent the rusting shortens the life of the bearing as rust is rubbed off between the bearing surface and neck.

Eighth: Do not drive bearing hard against thrust. Few plate mills have sufficient area that can be used to hold thrust. Run thrust as loose as possible.

Ninth: Do not allow bearing to run dry at any time. Composition is one of the best braking materials known.

L. F. Coffin: We have run composition bearings on all three plate mills at Sparrows Point since 1933, except for a few occasions when something happened and we had to put in bronze or babbitt on a real bad neck. There should not be much trouble with top necks if the rolls are properly lined up, but on bottom necks the prime difficulty is scale and there must be good scale guards. When you have trouble with the bottom neck there is nearly always scale present. A properly applied and protected scale guard can be installed.

The bearing pressures in our 160 in. plate mill can run up to as high as 4500 psi of projected area and in the three-high sheet mill to as high as 7200 psi.

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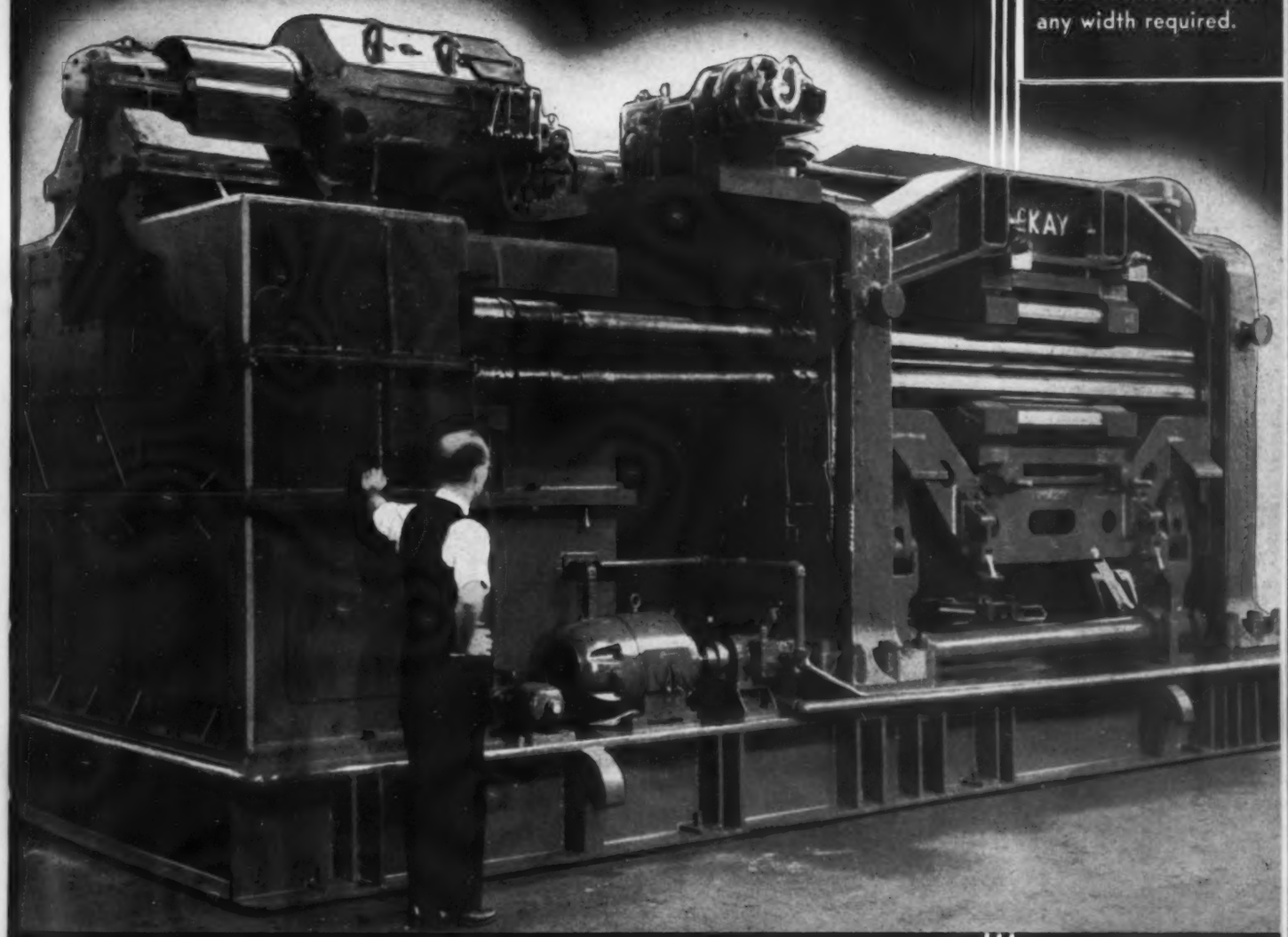
This leveller will flatten a wide range of thickness in plates and can be built to handle any width required.



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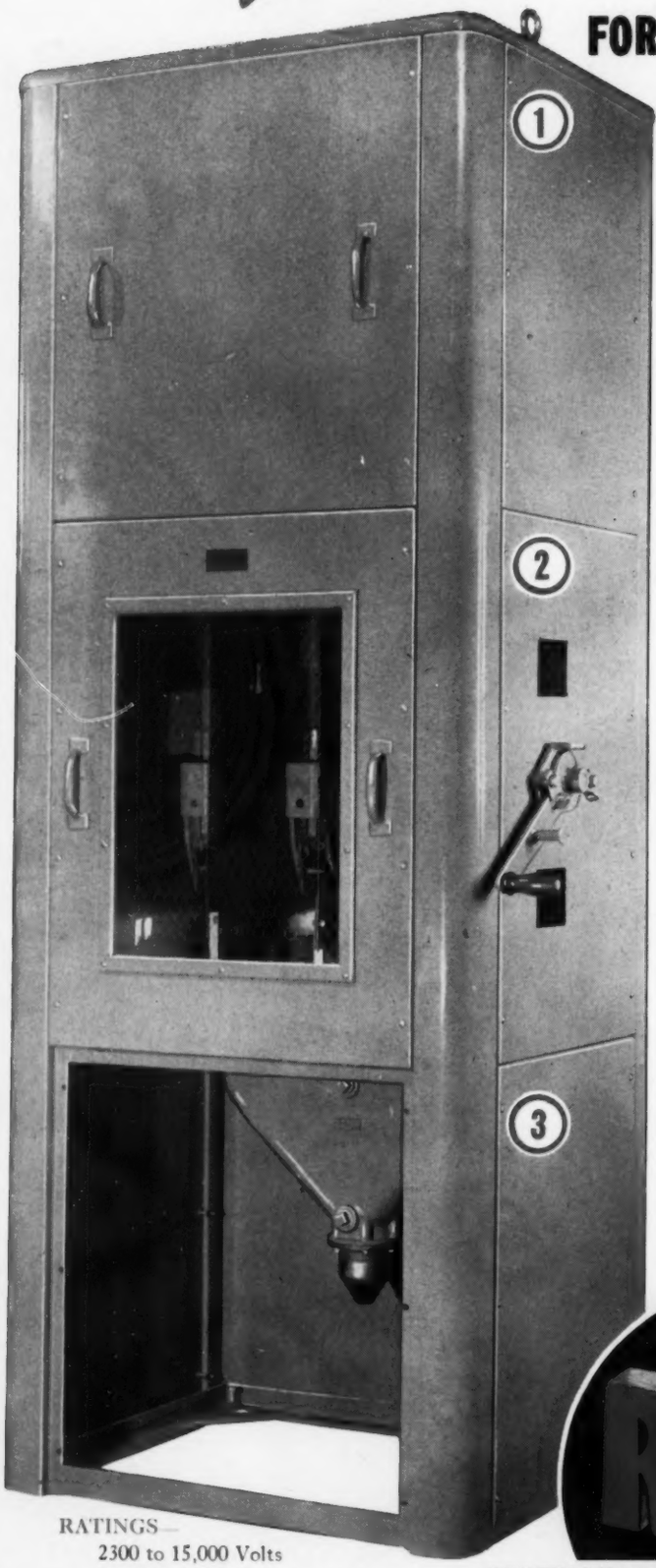

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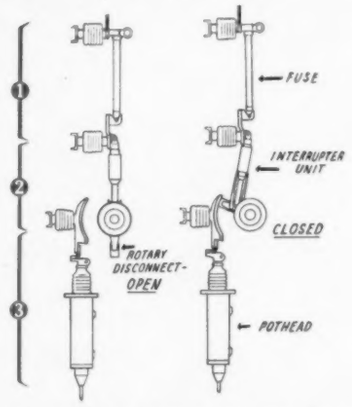

Arcs quenched in interrupter unit chamber when current is interrupted — then rotary disconnect establishes open gap.

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METAL CUBICLES

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TESTING DEVICES

H. L. Watson, Jr.: I was very much interested in Mr. Moses discussion concerning the spalling of rolls. We often have to conduct post-mortems on broken forged rolls for cold strip mills. These forged rolls are also subject to failures from detailed fractures which originate from a sudden overload in the mill. Very often these overloads are caused by the turning under of the edge of the strip with a resultant excessive load at the edge of the rolling track. This local overload frequently results in a sub-surface failure of the metal. When the roll has finally spalled, the area of the original failure will be found to be the nucleus for the detailed fractures, which take the form of a series of concentric lines growing outward from the nucleus. These detailed fractures keep growing until their unsupported area is so great that the roll finally spalls. I wish also to mention something in connection with fabric bearings for non-ferrous hot mills. It has been found that a mirror finished journal works far better with fabric bearings than a journal having only a commercial ground finish.

M. J. Conway: There is one question I wish Mr. Fisher to answer on heating, that is, to have him clarify what Bethlehem Steel Company at their Sparrows Point plant term heating defects and their methods of overcoming these heating defects.

W. H. Johnson: I would like to ask whether they have any hydraulic descaling on the bottom of the plate or have turnovers on the new mill or any of their mills.

Louis Bunting: On the new mill for the removal of scale we have a hydraulic spray directed at both the top and bottom surfaces of the plate. The water pressure is from 1000 to 1300 psi.

There is no turn-over in the new 120 in. mill but in the 206 in. mill we have a turn-over that is used on slabs weighing 25,000 lb or more. The capacity of the scale breaker in the 206 in. mill is 25,000 lb and above 25,000 lb we use a turn-over device to clean the surface of the bottom of the plate.

A. J. Fisher: Mr. Hall's question about the maximum size of ingots: Our plate mill furnaces are slab-heating furnaces, all heating slabs from a 56 in. breakdown slabbing mill. The predominating thickness of slab is 6 in. The range is 6 to 10 in.

Mr. Conway asked me to classify heating defects and what we have done about them. The thing we have done about heating defects is the design of the furnace which I have discussed. There are three heating defects caused by furnaces. First, there are brick marks. You are all familiar with a furnace becoming too hot, and the bricks melting and spalling on the slab and being rolled through on the plate and the plate subsequently being thrown out on inspection for brick marks. The second defect is burning. That is where the slab is heated to too high a temperature and kept at that temperature until you get an excessive amount of carbon reduction and the plate becomes very ragged and of course is rejected for that reason. The third item is rolled-in scale. Of course, in the more modern mills, hydraulic sprays are put in to take off scale, but if the heating is done properly scaling is not too difficult.

How does this furnace which I have described take care of these three defects? As to brick marks, they are taken care of by having a refractory of high fusion point in the roof, which, together with the automatic temperature control, prevents the burning or the dripping of the roof on the slabs.

The second defect, burning of the steel, is also controlled in the same manner. The furnace is controlled at 2475 to 2550 F which is aimed at a point just below the burning point or running point of scale. We try to run just as close to the melting point as we can and still not melt, so that we make a thick scale which will peel off easily in the mill on the first and second pass.

That brings up the third defect, which is rolled-in scale on the plates. In dampering the furnace automatically, when it reaches temperature, the furnace is filled with air — oxygen and nitrogen — and at the elevated temperatures of 2400 F slab temperature, scale forms very fast. If this scale is built up thick enough it will peel off easily in the mill.

L. F. Coffin: Anyone building a new plate mill should possibly follow the practice issued in continuous hot strip mills, where the bottom bearing rests on a hard strip so that bottom bearings are solf-aligning.

W. H. Johnson: Would you mind telling me whether brackish water could be used successfully on composition bearings?

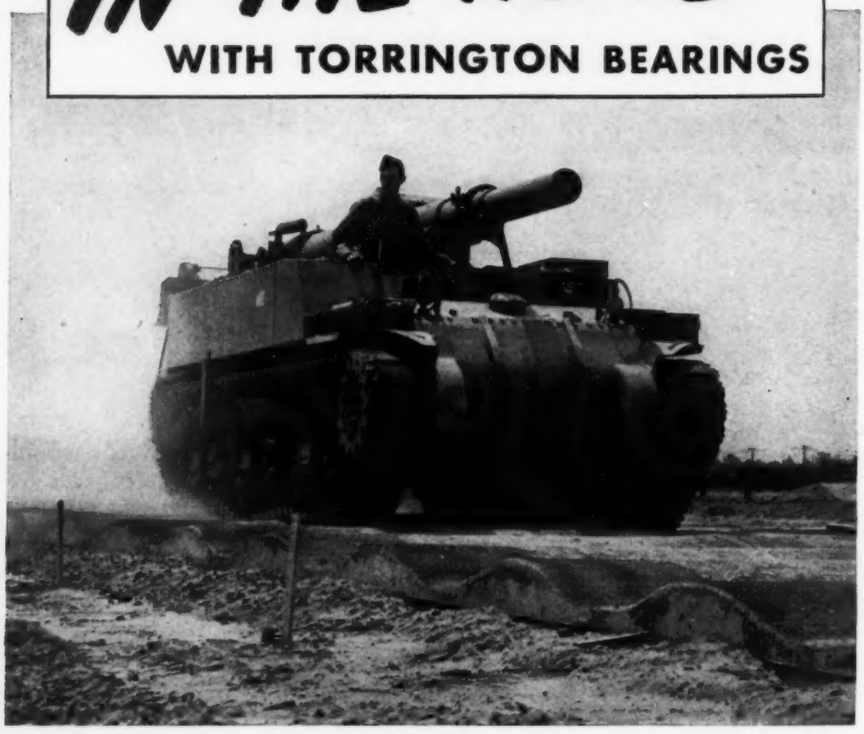
L. F. Coffin: Generally speaking, salt water or partially diluted seawater is not used on composition bearings.

D. Bruce Johnston: Although I have worked with Lukens Steel Company for a number of years, my experience with the actual rolling operation has been only from the standpoint of an observer. Listening to the paper given by Mr. Moses, I get the impression that the exact cause for roll spalling is not fully known. Mr. Moses himself has put forward some possibilities which he has illustrated by sketches on the blackboard. When watching plate being rolled, particularly on the large 206 in. mill at Lukens, the throwing of salt on the surface of the plate for the purpose of descaling causes sufficiently violent explosions that the ground in the vicinity of the mill seems to vibrate. The unit pressure required for rolling is of a high order and rises sharply as the plate gauge decreases. Apparently, these explosions occur at the moment the plate is entering the rolls and while I appreciate the fact that the noise is no measure of the forces generated by these explosions, nevertheless, it appears to me quite conceivable that an occasional explosion might be of sufficient violence to cause initial damage to one point at or near the surface of the roll, which damage is aggravated by subsequent rolling operations. I would regard such forces as shock loads applied locally and, as such, more capable of doing local damage than the greater, but more uniform loads occasioned by rolling.

I would like to know whether there is any positive information regarding the effect of these explosions or whether their value is of such a low order compared with the normal rolling loads as to be inconsequential.

T. T. Watson: We have never found any roll damage from the explosions from salt. Salt is thrown on the hot plate and is quickly melted and the molten salt coming in contact with water causes the explosions. The number and intensity of the explosions are merely increased by the passing of the plate through the mill.

IN THE NEWS
WITH TORRINGTON BEARINGS



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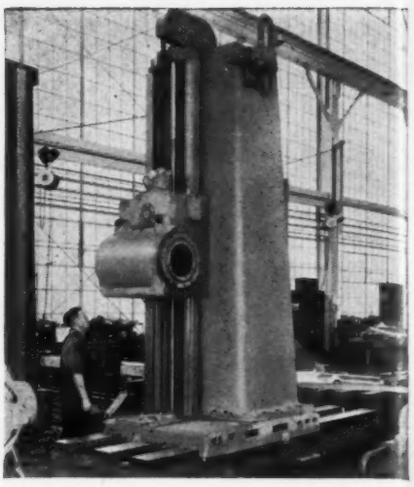
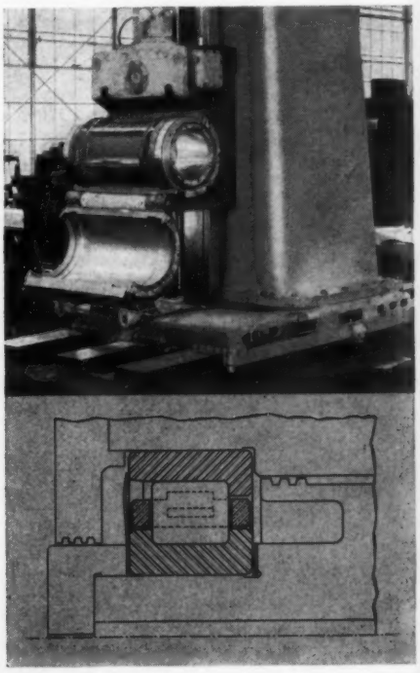
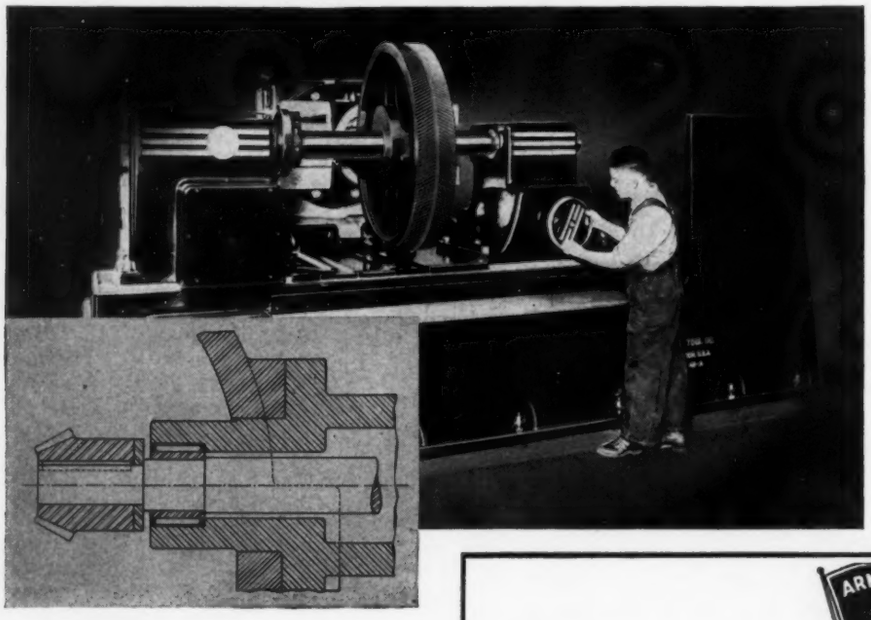


SUPPORT FOR A 24-FOOT BORING BAR is the job of this large end support bearing for a floor type horizontal boring, drilling and milling machine photographed in the shops of Giddings & Lewis Machine Tool Company. Supporting this huge shaft in the housing shown open in the close-up photo (below) are two special 18-inch O. D. radial roller bearings supplied by Torrington's Bantam Bearings Division. These bearings illustrated in the cross-section illustrate the type of service Torrington is equipped to render in the design and manufacture of special bearings to meet the unusual and out-of-the-ordinary bearing requirements. Why not TURN TO TORRINGTON for specialized assistance on your next bearing problem?





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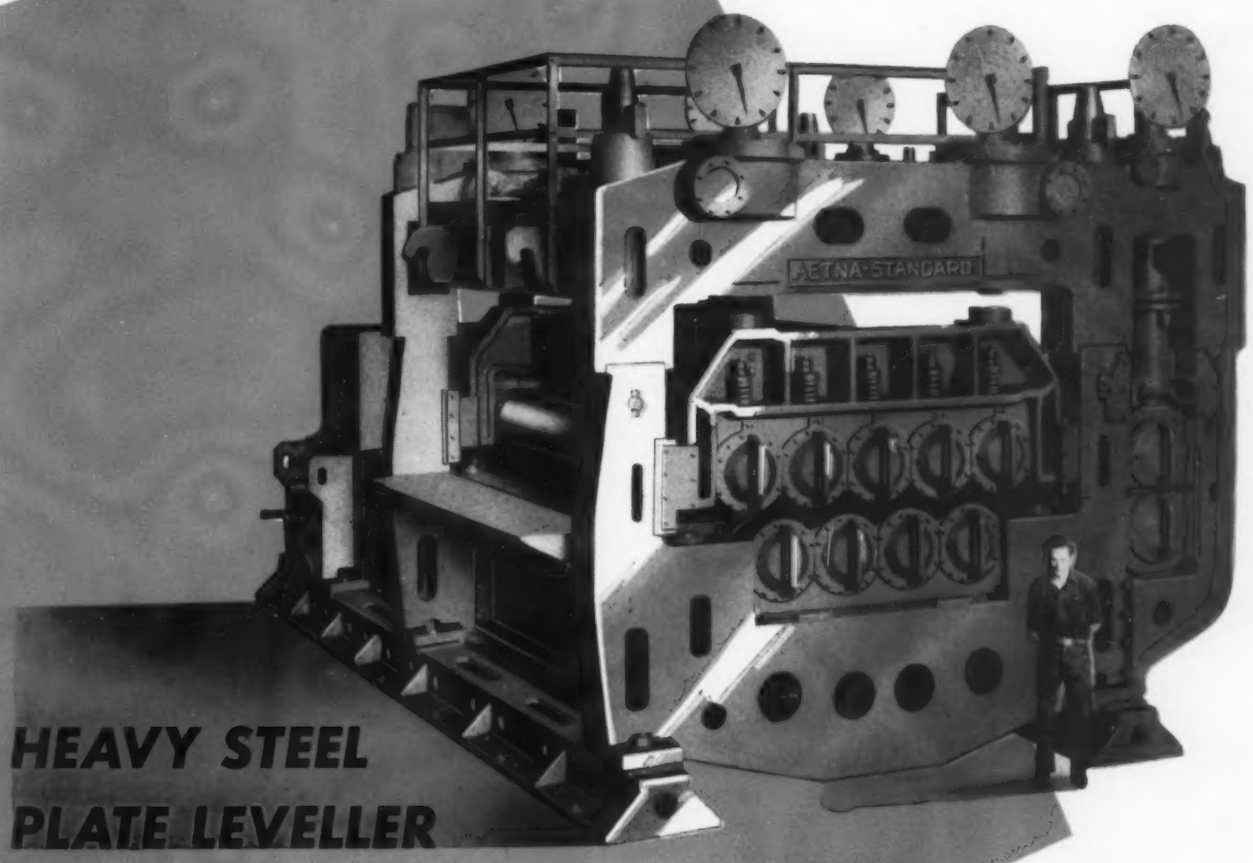

HEAVY STEEL PLATE LEVELLER

This 200-ton giant flattens hot, heavy, alloy plates as fast as they come from the rolling mill . . . 100 to 300 feet per minute.

Plates ranging in thickness from ¾ to 1¼ inches can be levelled by the powerful action of the 140-inch rolls which move on anti-friction bearings. Each roll is 18 inches in diameter. A special designed motor screw-down enables the operator to readily adjust the top bank of five rolls in any direction.

This production machine was designed, built, and installed in record-breaking time . . . another example of Aetna-Standard precision engineering at work. The thousands of tons of ship plates, processed through this leveller, passed the rigid inspection standard with flying colors.

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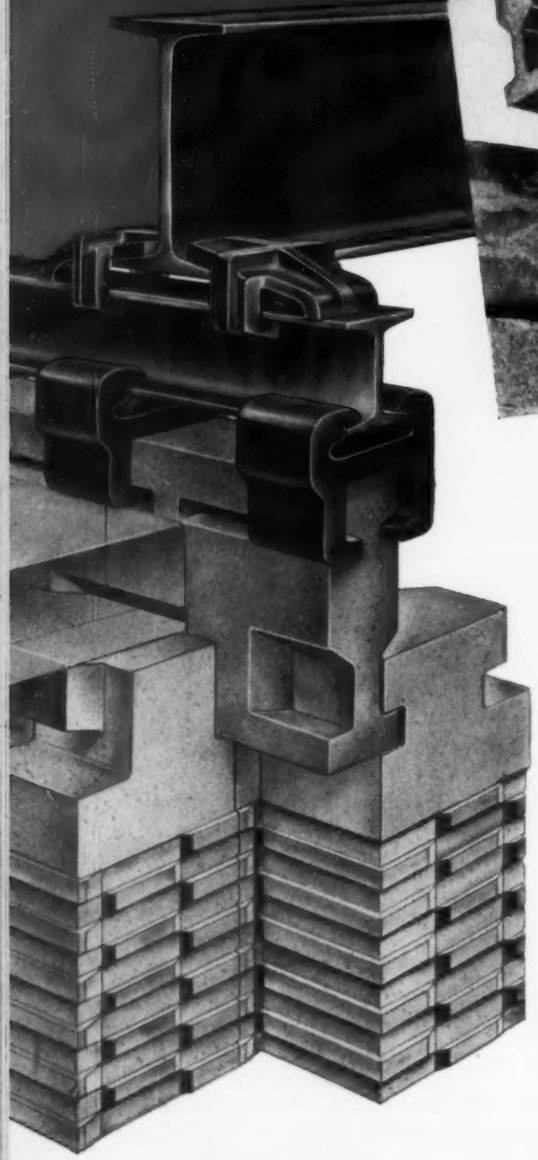

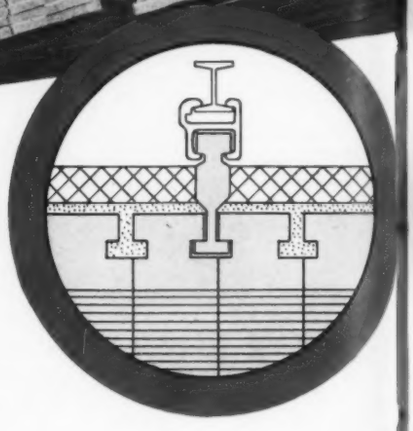

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FACED with the demand for higher steel furnace temperatures Detrick engineers have provided a Refractory Hanger Arch that is able to take the punishment of long runs and extreme temperatures. Starting with the Detred tile which provides tightness of refractories it was a logical step forward to provide a refractory hanger which makes it possible to properly seal and insulate the top of the roof.

This prevents the passage of air or gas and provides a low heat loss and uniform refractory temperature, resulting in less spalling and slower fusing of the refractories. Proof of this performance lies in the fact that this roof construction has been in service on In and Out furnaces, Continuous type furnaces and Open Hearth checker chambers.

Complete details of this construction are shown on pages 56 and 57 of the new Detrick Catalog.

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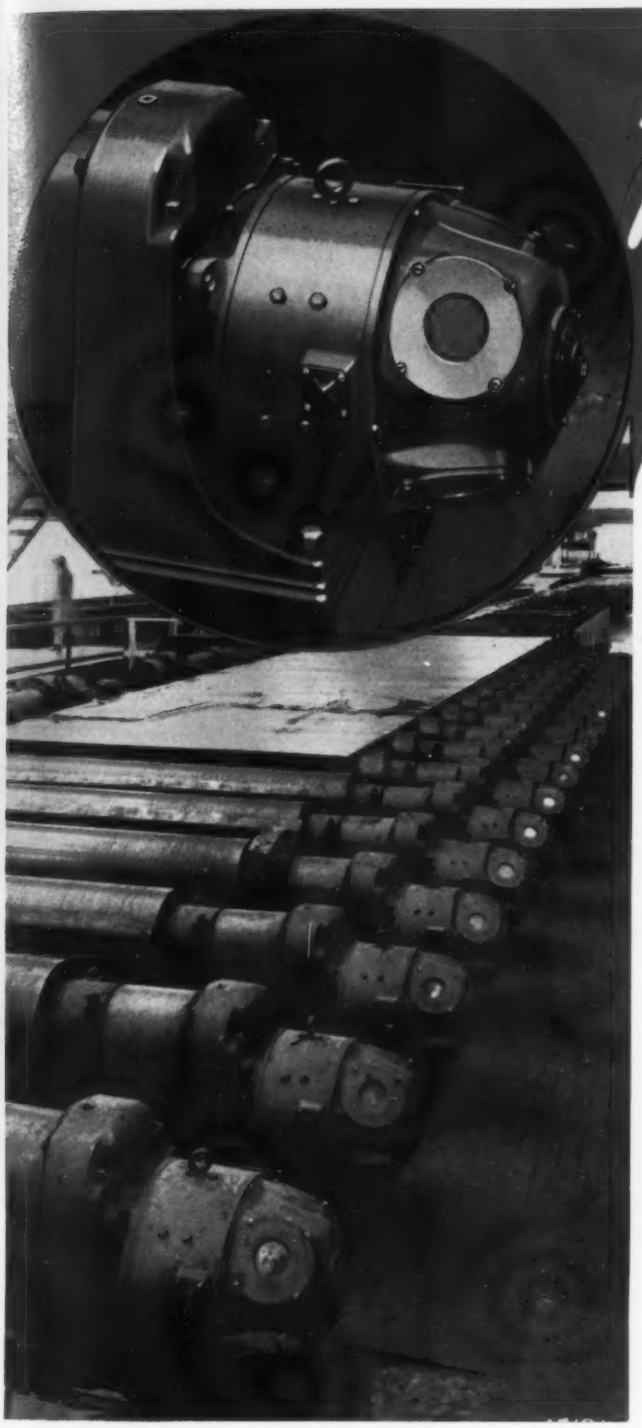

No Traffic Jams on THIS INSPECTION TABLE!

The fact that doing it electrically with Reliance Motor-drive helps to keep plate traffic moving steadily over this inspection table is only part of the story. Proving again that *motor-drive means more than power,* the Reliance table drive also contributes these steady-production features:

Clear access between rolls for under-side inspection.

Ability to start, stop and reverse rolls smoothly, with quick acceleration and deceleration.

Table speeds variable to suit plates of different sizes and thickness.

And, because of its individual drive, a single roller can be readily removed for repairs — a damaged roller doesn't hold up production.

Any Reliance man will be glad to furnish you details regarding this and other applications of Reliance Motor-drive which can help to promote better production and lower costs in modern plate mill operation. Call our nearest office, or write directly to us at Cleveland.

140" Plate-mill Inspection Table. Rollers individually driven by D-c Reliance Gearmotors 4.3 to 1 ratio. Enclosed motor units with Class B insulation. Speed control by voltage control.

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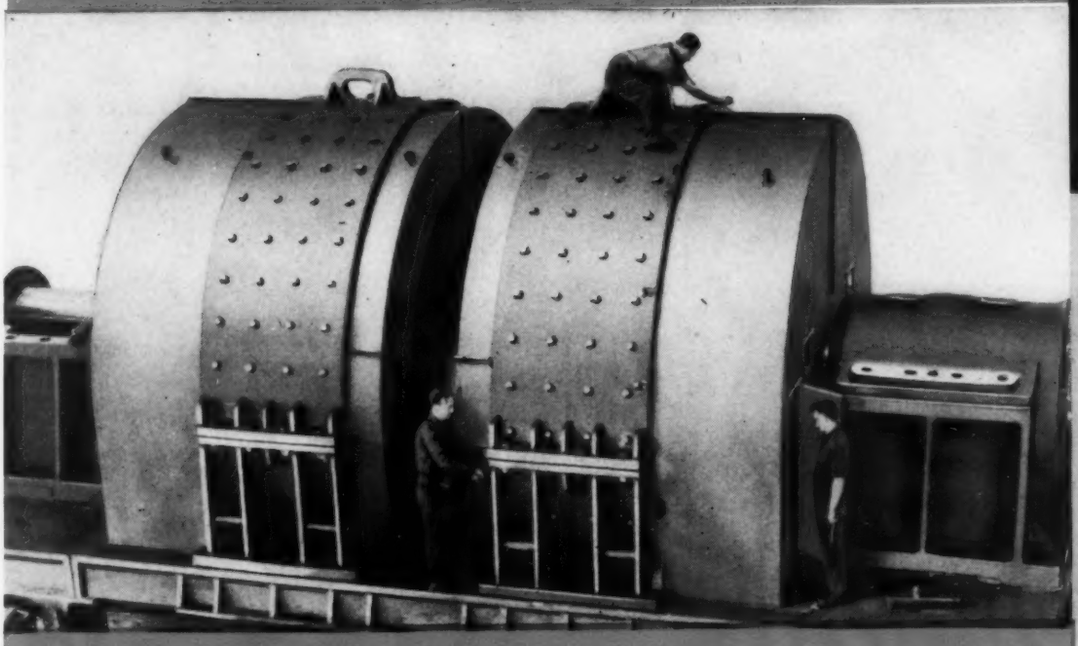

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DEVELOPS a maximum torque of 4,100,000 pound-feet—rated 7000 hp, 25 to 60 rpm—was designed and built for Geneva Steel Company by General Electric. Drives a plate mill that produces steel plates from billets weighing as much as 20,000 pounds.

This is another example of the application of experience and skill by G-E engineers to solve a problem created by today's needs. From the electrical standpoint, General Electric is *first:* in the number of complete-mill layouts; in installed horsepower of electric equipment in steel mills; and in special developments to solve the problems of the mill engineer. General Electric will be glad to help you meet your electrical requirements. *General Electric Company, Schenectady 5, N. Y.*

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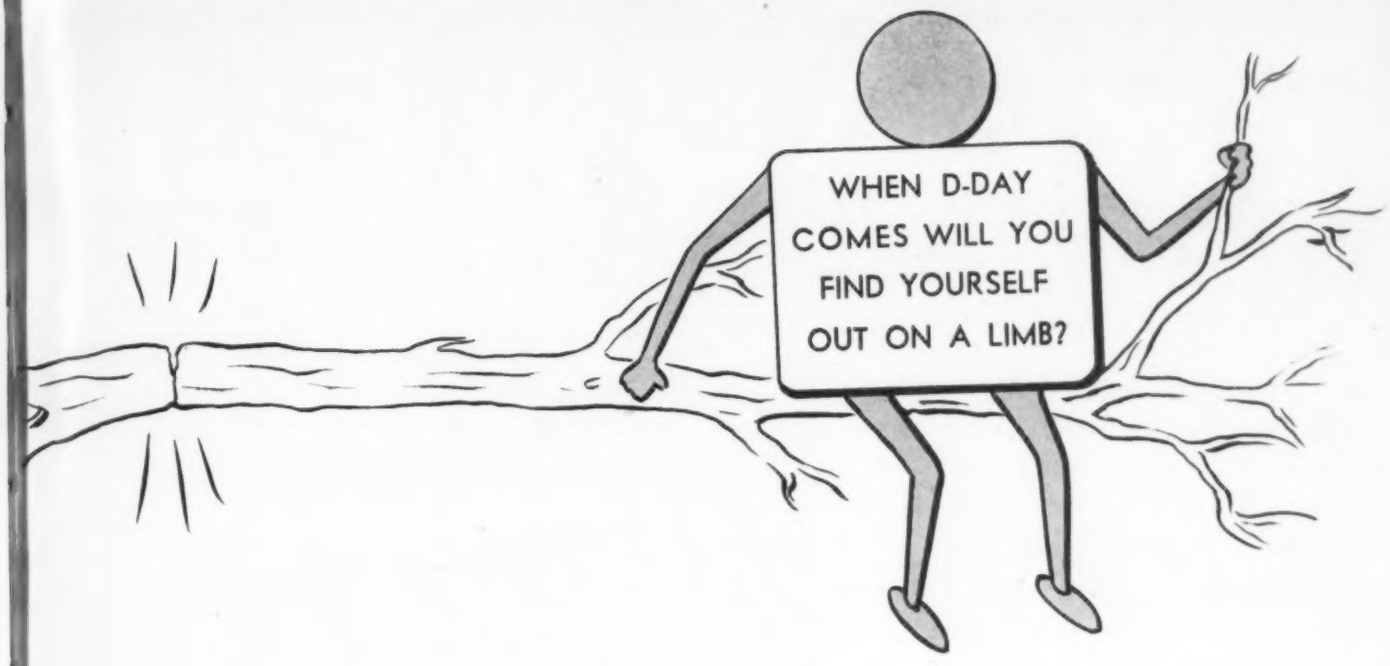

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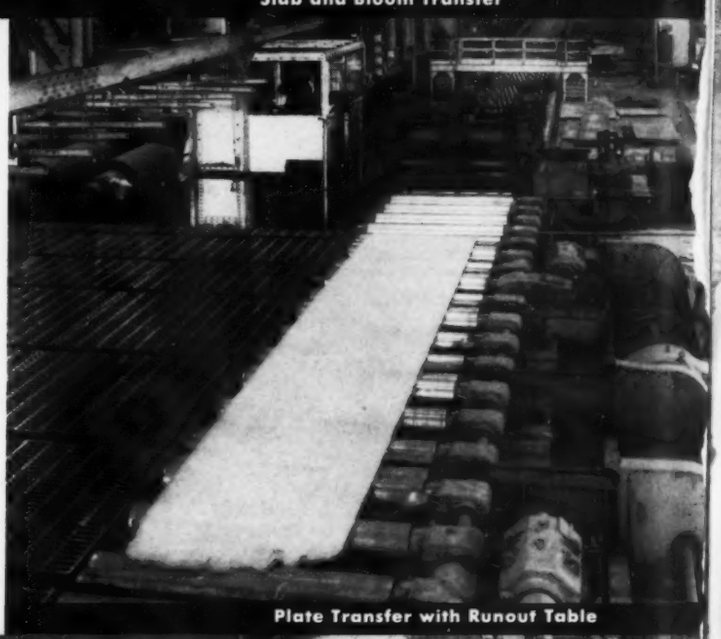

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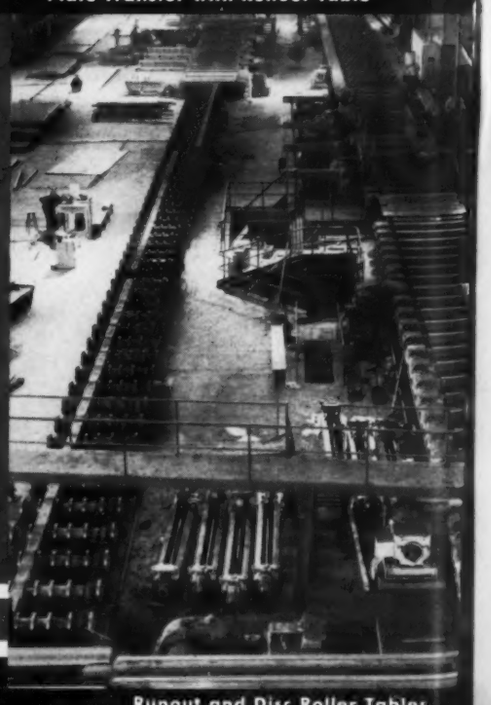
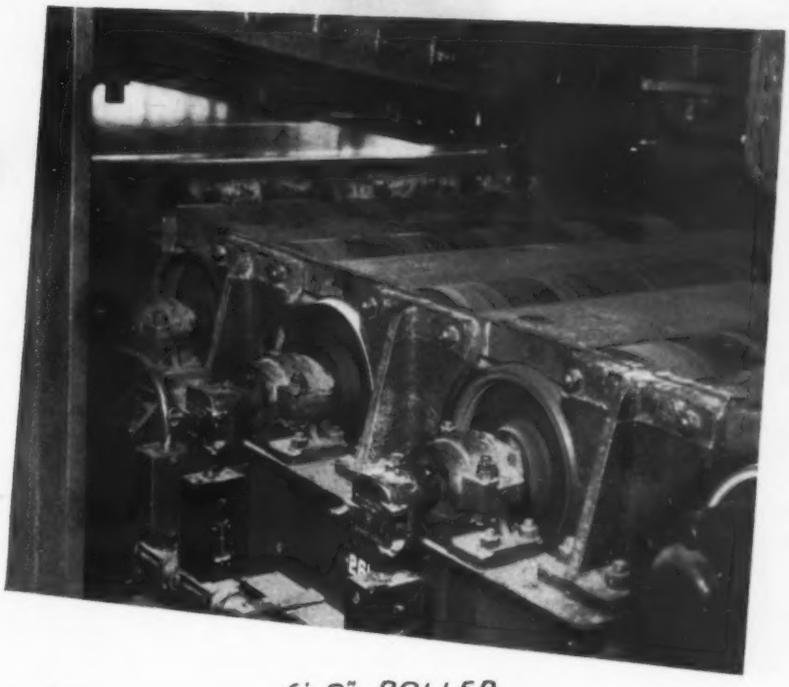
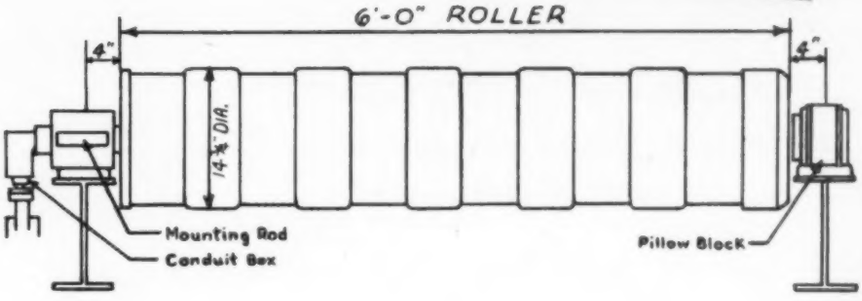


Runout and Disc Roller Tables

SCHLOEMANN "Motor-Rollers"

for Installation in Limited Space





HERE'S WHY . . .

Note large percentage of roll surface available in comparison to over-all dimensions. "Motor-Roller" simplicity of design thus affords maximum efficiency in minimum working areas.

★ Illustrated is a "Motor-Roller" installation in a shear depressing table of a 100" plate mill. It graphically demonstrates how a Schloemann table can be engineered to meet special requirements—can be installed where conventional roller tables are inadequate because of bulky fixtures and attachments.

Simplicity of mechanical and electrical design is due largely to the self-contained squirrel cage motor powering individual "Motor-Rollers." The stator has no electrical connection to the rotor and represents the simplest piece of apparatus for converting electrical energy into mechanical work. The free turning shell also permits each "Motor-Roller" to act as an idler roller when the current supply is disconnected.

Operating and maintenance expenses on shear, scale, or mill tables are lowered with "Motor-Rollers." Their rugged mechanical design employs a minimum number of rotating parts.

In addition to "Motor-Rollers," Schloemann experience and skill is utilized in the construction of air-hydraulic accumulators, accumulator controls, complete hydraulic systems, and extrusion presses. Each installation is specifically designed and engineered for particular requirements.

SCHLOEMANN
ENGINEERING CORPORATION

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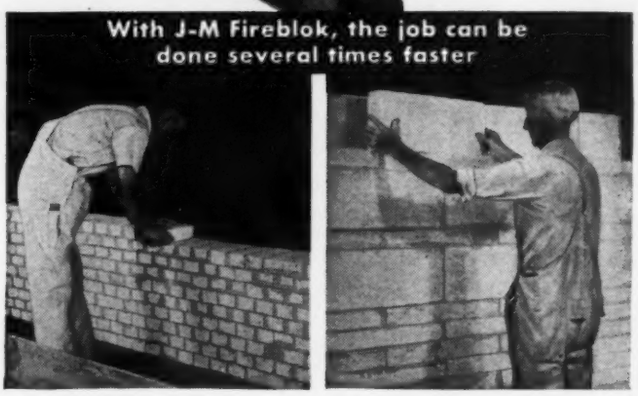
NEW TIME-SAVING REFRACTORY LINING



Johns-Manville presents
INSULATING FIREBLOK
to make possible faster, more efficient installations

THESE FOUR new light-weight J-M Insulating Refractory Linings are suitable for the same service conditions and range of temperatures as the four well-known J-M Insulating Fire Brick. The only difference is in size . . . a single Fireblok covers more surface than five full-size brick.

The large, convenient size of Fireblok provides many advantages. The greatest, perhaps, is the reduction in installation time, minimizing down time and consequent loss of production. On most jobs Fireblok linings can be installed in considerably less time than is required for standard size brick. The many hours thus saved help to keep production schedules at their peak. Fireblok has these important features, too:

Easy cutting and fitting—J-M Fireblok can be easily cut with a saw and shaped with a rasp. Most special shapes can be either shop or field cut from standard slabs, reducing the inventory of special shapes.

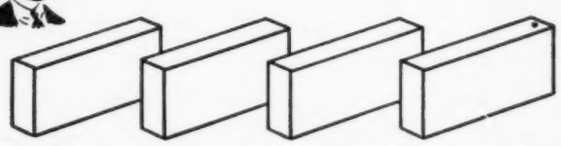
Minimum of Joints—the large size, compared to the standard fire brick unit, materially reduces the number and length of joints, resulting in a thermally more efficient construction.

Economical Bonding—with reduced joint length Fireblok requires a minimum of air-set cement for bonding. (J-M 1626 Cement was especially developed for this use.)

Uses—Fireblok can be used wherever Insulating Fire Brick are recommended such as for heat-treating furnaces, flues, stacks, mains and similar equipment. Also for the lining of doors, suspended arches, and, when tapered, for sprung arches of exceptional stability.

Write for new booklet, IN-103A, on this J-M development. Johns-Manville, 22 East 40th Street, New York 16, New York.

"J-M INSULATING FIREBLOK ARE NOW AVAILABLE!"



JM-1620 Fireblok	JM-20 Fireblok	JM-23 Fireblok	JM-26 Fireblok
for exposed temp. to 1600° F. As back-up to 2000° F.	for use up to 2000° F. Exposed or back-up	for use up to 2300° F. Exposed or back-up	for use up to 2600° F. Exposed or back-up

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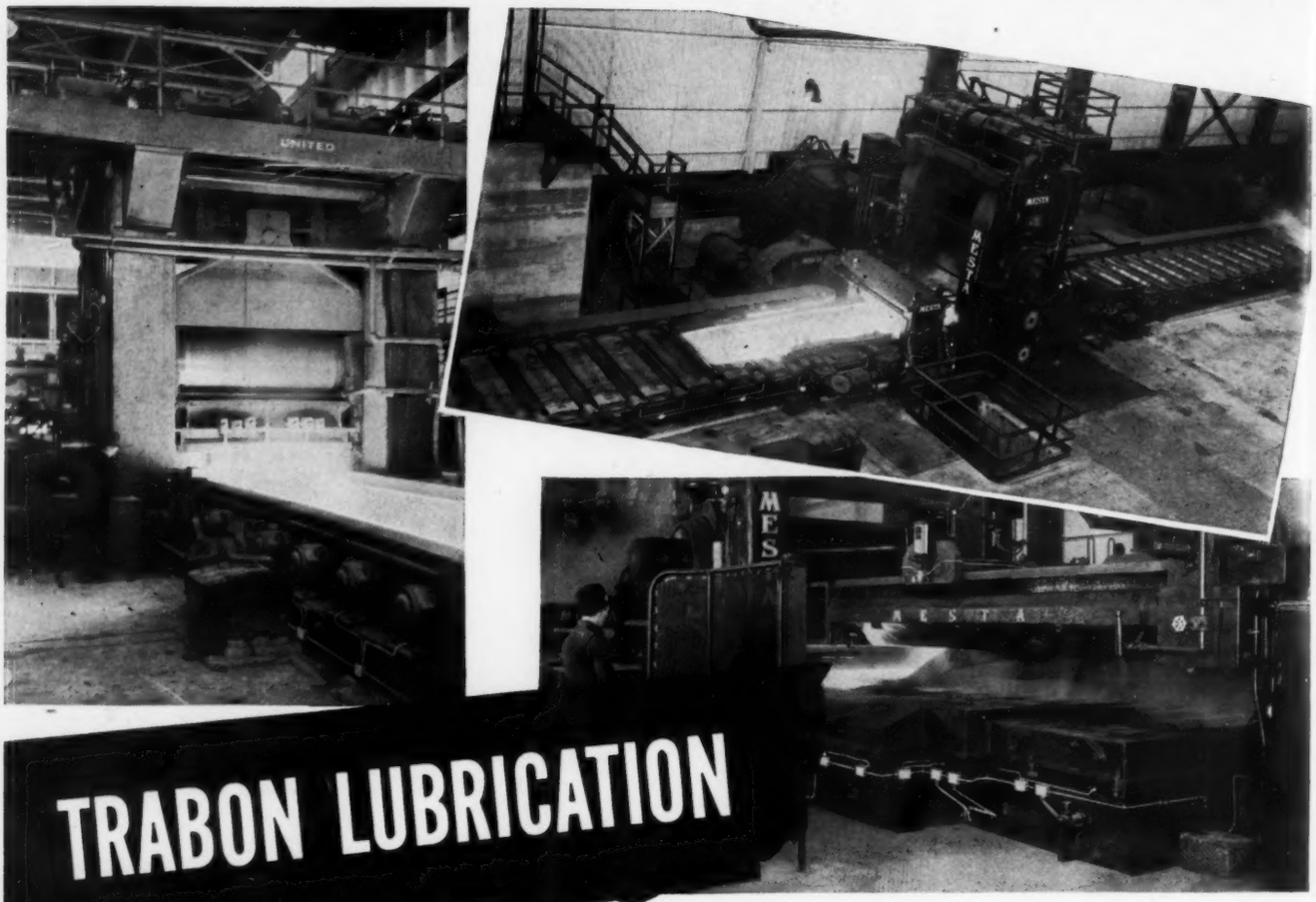

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● Widely used on plate mills, slabbing and sheet mills, revolving blast furnace tops, overhead traveling cranes, and a wide variety of other heavy duty equipment—Trabon lubrication "keeps them rolling" hour after hour, day after day—has played an important part in establishing one production record after another.

Trabon lubrication makes absolutely certain that every bearing receives just the desired amount of lubricant *while the mill is in operation.* It prolongs bearing life,— avoids breakdowns and production tie-ups . . . minimizes accidents and compensation costs.

Thoroughly dependable, and less costly operation, are only two advantages of Trabon Lubrication. The use of fully enclosed "feeders" that have no exposed moving parts to corrode or get bent, — easy installation,— and the ability to place the feeders in the most advantageous positions, even though they be hidden from view, are some of the others. You will find full details in our recently issued fully descriptive Engineering Bulletins. Send for copies today.

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INDUSTRIAL LUBRICATION EXCLUSIVELY SINCE 1922

Clevelands on the Modern Plate Mill

Representing the thousands of Cleveland Worm Gear Speed Reducers installed by the Steel Industry since 1917, the sturdy Unit shown here is the symbol of dependable operation. It stands nearly six feet above floor level and weighs more than 3½ tons.

Throughout the Mill, trustworthy Clevelands are delivering continuous power to Pushers, Coilers, Screwdowns, Tilters, Pullbacks, Transfers, Shears, Cranes—and to more than 100 other applications. They stand the gaff—require but nominal maintenance—with no parts replacements for years on end.

Specify Cleveland Worms and Gears for the new equipment in *your* Modern Mill—insure the trouble-free operation of your Drives for many years to come.

The Cleveland Worm & Gear Company,
3278 E. 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication
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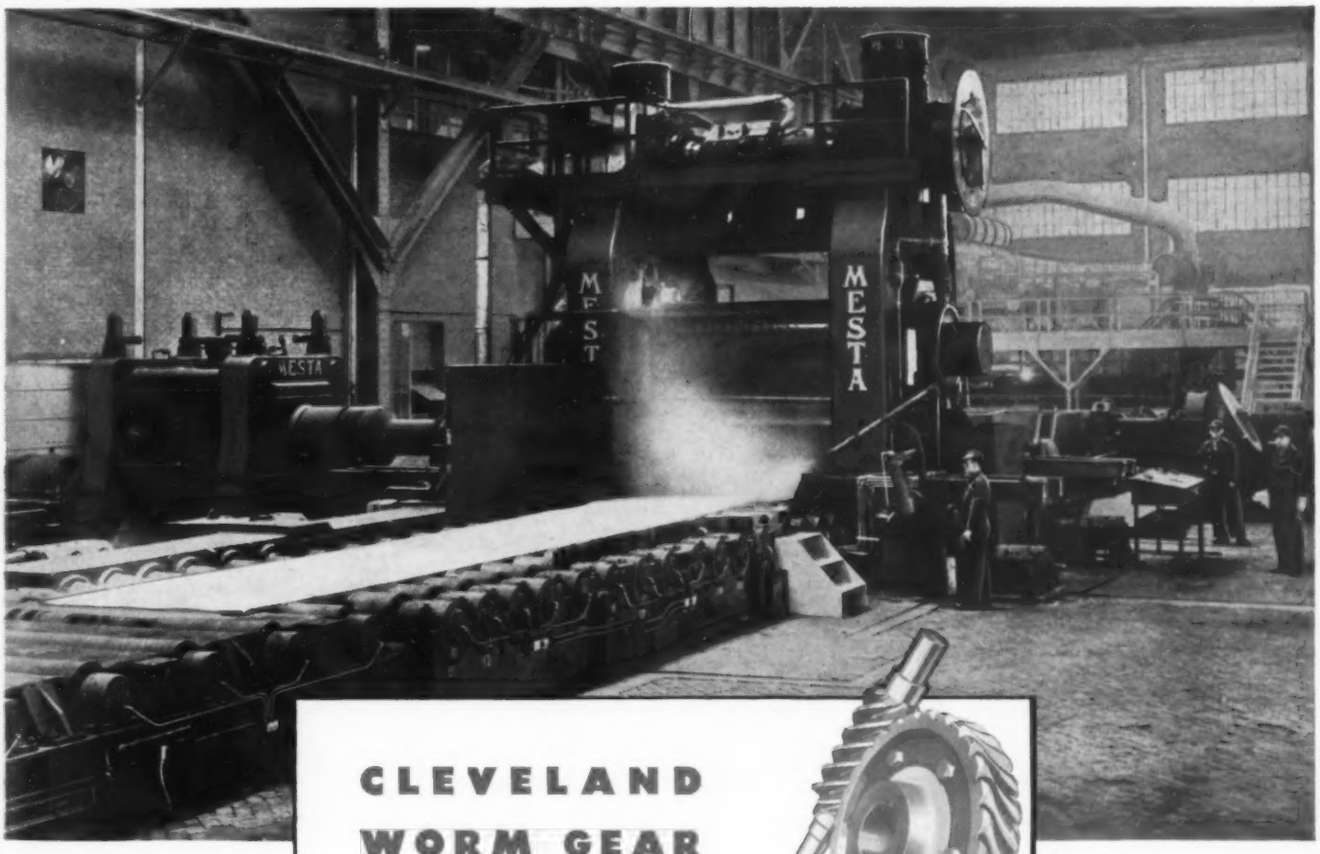

CLEVELAND
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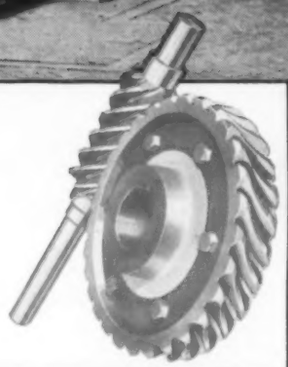
SPEED REDUCERS



Farval on the Modern Plate Mill

Twenty-four hour operation of the Modern Plate Mill leaves no time for shutdowns to lubricate—or to repair the failure to lubricate. A modern centralized system of lubrication is indispensable to production.

Proper lubrication of your older Mills is even more essential and will show greater earnings.

On one 3-Hi Plate Mill, for example, savings of $15,000.00 per month were made by the reduced rejections resulting from better lubrication. Life of top brasses was increased by more than 25 times, giving an additional saving of $15,000.00 per year.

By eliminating the shutdowns formerly required to lubricate another large Plate Mill by hand, Farval has helped to increase output by 375 tons per day.

Power savings are reflected in a reduction of amperage load of approximately 10%, while at the same time overall lubricating costs were reduced 15%.

Bring your present equipment up-to-date. Install a Farval Centralized System and you will be able to better compete in the postwar market.

The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

FEEDWATER TREATMENT AT Weirton's High-Pressure Station

. . . . operation of 800 psi boilers and topping turbo-generators has been very satisfactory from both the operating and maintenance standpoints . . . .

by J. H. Strassburger, MANAGER
DEPARTMENT OF SERVICE AND MANAGEMENT
WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA

▲ DURING the year 1935 the Weirton Steel Company completed an investigation and study of the use of high pressure steam for the generation of power by the use of a topping turbine installation. A survey was made of high pressure plants utilizing 600, 800, and 1200 psi steam pressure. The main boiler and power plant at Weirton at that time was utilizing steam at 225 psi, 500 F total temperature, and an old 150 psi saturated plant had reached an age where the boiler plant required complete replacement. The installation of a high pressure topping plant was required not only for an increase in power production, but also to replace this 150 psi saturated boiler plant which had a developed capacity of about 12,000 boiler horsepower. The 800 psi, 800 F temperature was selected as the throttle conditions for the topping turbine installation with exhaust conditions at 225 psi, 540 F total steam temperature.

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 28-30, 1943

The selection of the 800 psi top pressure was dictated by both the requirement for process steam and by the available source of feedwater. The feedwater available for a high pressure installation consisted of a 100 per cent make-up plant utilizing a hot process lime-soda softener. The make-up water available for feedwater at the Weirton plant was Ohio River water which fluctuates rapidly in hardness, total solids, and turbidity. The high pressure plants operating at the time of our investigation indicated that there had been more experience in operating plants at 600 to 800 lb pressure with a large per cent of make-up than with the plants operating at the higher pressure of 1200 lb.

After having made the decision to install the 800 lb plant, the selection of proper equipment was of prime importance so that a good operating plant could be provided for. The type of boiler to be used was studied very carefully and after due consideration the selection of a multiple drum, bent tube boiler was decided upon. The type of feedwater to be used was a major factor in making this decision. A boiler of relatively large heating

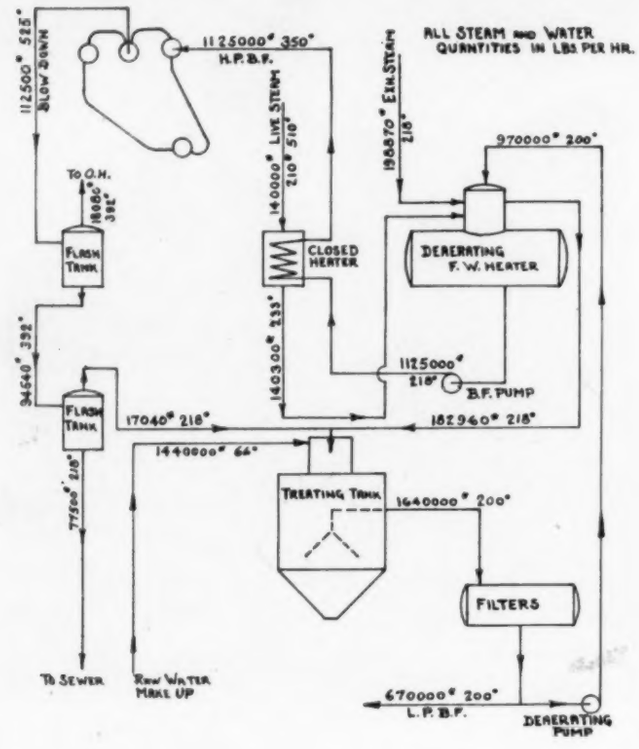


Figure 1 — Feedwater flow diagram of Weirton 800 psi steam plant.

surface with steam drum volumes sized so as to make possible a good separation of steam and water was specified and in line with this same thought the completely water cooled boiler furnace was made of large volume. With this design of unit it would be possible to generate the steaming capacity with a heat release in the furnace of approximately 25,000 Btu per cu ft at the normal boiler rating and not over 31,000 Btu per cu ft at the maximum boiler rating. The size of the boilers was also determined so that the steam released per foot of boiler width would be relatively low. Under normal steaming conditions a production of 12,500 lb of steam per hour per foot of boiler width is indicative of the conservative design selected.

The 800 lb plant at Weirton was built in two steps. In 1936 two boilers with a maximum capacity of 400,000 lb of steam per hour each and one 10,000 kw topping turbine were installed, and in 1940 a third boiler and a second 10,000 kw generator were added to the existing plant. The steam drum was provided with a steam washer using feedwater for scrubbing the outlet steam and this drum was made larger than the standard size drum for this type of boiler. All of these basic points of design were made with the idea of maintaining a relatively low steaming capacity both in the furnace and in the boiler and to provide ample steam space for the production of dry steam. With the use of 100 per cent make-up feedwater it was deemed necessary that the steaming surfaces be of ample size so that excessive rates of evaporation would not be encountered and also that the type of boiler be such that good circulation would be available. The boiler units are of relatively simple design with large air heaters for the recovery of stack heat rather than by a combination of smaller air heaters and economizers.

FEEDWATER EQUIPMENT

When the original installation was made in 1936, we had available a hot process lime-soda water softening system consisting of a 320,000-gallon hot process tank rated at 160,000 gal per hr followed by the conventional bank of pressure filters. This system was supplying the feedwater to the 225 lb boilers. With the construction of the original high pressure plant in 1935 and 1936 additional pressure filters were added to take care of the increased flow of feedwater from the sedimentation tank. The feedwater after passing through the filters was delivered to a booster pump which pumped the feedwater to an elevated deaerating heater and storage tank. From this storage tank the feedwater flowed by gravity to the feed pumps which pumped the water through a double set of blowdown heat exchangers to the high pressure boilers. In order to properly treat the water for the high pressure boilers, an auxiliary treatment of sodium hexametaphosphate was selected and the phosphate was introduced into the feedwater system in the suction line to the high pressure feedwater pumps. In this original installation the feedwater was heated to a temperature of approximately 230 F in the blowdown heat exchanger system, and the method of introducing phosphate worked out satisfactorily for this original installation although a somewhat higher excess of phosphate was maintained in the boilers than was considered necessary.

With the addition of a third boiler in 1940, the feedwater system was altered and the blowdown heat exchangers were eliminated and replaced by a double set of flash tanks. The feedwater was then heated in a high pressure feedwater heater utilizing 225 lb steam. This heater provided a feedwater temperature of 350 F going to the boilers. With this type of system the introduction of phosphate at the boiler feed pump suction would have caused a breakdown and deposition of sludge in the feedwater heater so that at this time high pressure phosphate feed pumps were installed for introducing the phosphate into the mud drum of each boiler independently. This system has worked out very well and a lower excess phosphate is carried in the boilers than was carried previously when the phosphate was introduced by a shot feed method in the feed pump suction and a closer control of phosphate to the individual boilers is possible.

In the second installation in 1940 a second 320,000 gallon sedimentation tank was added as well as additional filters and a second deaerating heater and storage tank of the same size and capacity as the original deaerating heater. As previously stated, the original two boilers were installed with a spray type steam washer in the rear top steam drum. When installing the third boiler in 1940 the spray steam washer was omitted but the scrubber plates were installed as in the original installation. There was some question at that time as to whether the spray steam washer was of real benefit. After operating the third boiler for approximately one

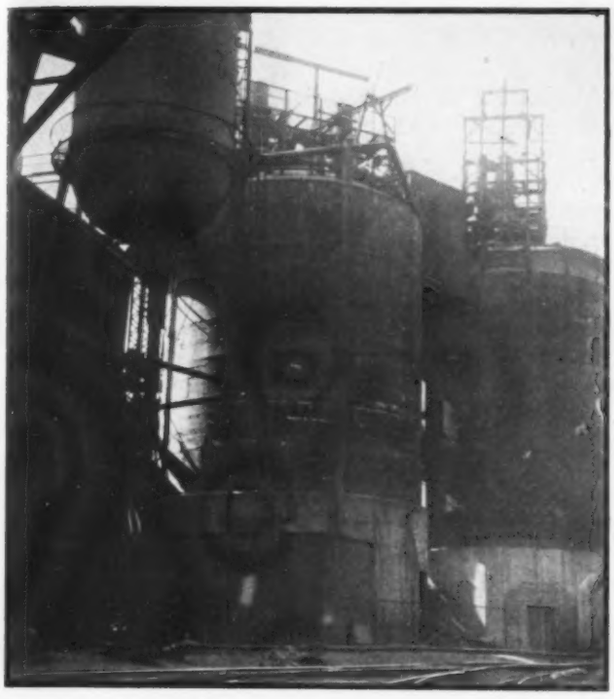


Figure 2 — Two sedimentation tanks, each of 320,000 gal capacity, provide liberal settling time for the treated water.

year's time we found that the quality of steam from the No. 3 boiler without the feedwater spray washer was not as good as the quality of steam from the original two boilers. With the change in steam piping between the boilers and the turbo generators, the flow of steam from the three high pressure boilers was piped so that 100 per cent of the steam from the new No. 3 boiler was delivered to the No. 6 generator. We noted that after No. 3 boiler went in operation that the No. 6 turbine lost capacity in a shorter period of time and required more frequent washing out of the turbine blading than previous to the installation of No. 3 boiler. We therefore installed the spray scrubber in the third boiler identical with the one in the original two boilers. With the spray steam scrubbers installed in all three boilers the average carry-over of dissolved solids in the steam amounted to about .5 ppm.

FEEDWATER TREATING PROCEDURE

The feedwater for both the high and low pressure boilers is handled in the same system. Two men per shift are used for operating the feedwater equipment together with the low pressure feedwater pumps. One man runs all of the analyses and makes adjustments in the treatment and maintains the desired limits on the boilers. He is designated as the filter operator. The low pressure pump operator operates the low pressure boiler feedwater pumps, the phosphate chemical pumps, washes the filters, charges the soda ash and lime tanks, and gives the filter operator assistance in running analyses on the water. The filter operator samples the high pressure boiler water every two hours and the water tender on the low pressure boilers obtains the boiler water samples from the low pressure boilers every eight hours. Incoming raw water samples are taken and tested every four hours. The raw water for the boilers is taken from the river service lines adjacent to the boiler house. This water is delivered by river pump pressure direct to the two 320,000 gallon capacity hot process sedimentation heater tanks. With the available Ohio River water as the 100 per cent make-up supply for the feedwater system, we have found that the large capacity of the feedwater system with the two large sedimentation tanks has been a decided benefit in taking care of treating a make-up water with large fluctuations in quality. The large capacity of the feedwater treating system has a flywheel effect in ironing out the quality of the treated water.

These two tanks are connected by an equalizing line to maintain the same level in both tanks. Exhaust steam from the boiler auxiliaries and from the plant service pumps is used to heat the water. Four jet heaters are located at the top of each tank for mixing the exhaust steam with the incoming water. Vent condens-

Figure 3 — Controls and instruments for the three high pressure boilers are mounted on these panels.

ers are located on the top of each sedimentation tank for condensing the vented steam vapors. In 1940 propeller type agitators were also installed in both tanks in order to aid in the mixing of the chemicals and to accelerate the feedwater chemical reactions. The total feedwater handled for both high and low pressures amounts to about 1,700,000 lb per hour, or over 200,000 gallons per hour. With a total sedimentation tank capacity of 640,000 gallons there is approximately three hours settling time on the hot process softeners. We have found that this capacity is of great advantage in obtaining good chemical reaction and settling of the sludge and the production of a good quality water from the sedimentation tanks before the water is delivered to the filters for final clarification. Soda ash and lime are used in the hot process tanks for water treatment. Approximately 550 lb of soda ash and 150 lb of lime are used per charge, with about 10 charges in 24 hours. The soda ash charge amounts to about .135 lb per 1000

lb of water and the lime charge amounts to .038 lb of lime per 1000 lb of water.

As previously stated, the water after leaving the sedimentation tank is delivered to a bank of eight 8 ft x 25 ft horizontal pressure filters. The filters are filled with anthracite coal as the filtering bed medium. The suction pressure on the exit side of the pressure filters is maintained at 20 lb and two filters are backwashed every 24 hours. A backwash pump with a capacity of 2300 gpm at 65 ft head is used in backwashing the filters and to return the backwash water to the sedimentation heater tanks. The water from the filters splits in two ways — about 40 per cent of the treated feedwater flows by gravity to the low pressure boiler feedwater pumps, and the remaining 60 per cent flows by gravity to the deaerator booster pumps which pump the feedwater to two elevated thoroughfare type deaerating heaters. Each heater is rated at 600,000 lb of water per hour at .00 cc of oxygen per liter by the Winkler test. The deaerating heaters are of the tray type and each is equipped with a 30,000 gallon storage tank. The feedwater is raised in temperature from 210 to 218 F in passing through the deaerating heaters. The two deaerating heaters are cross connected both on the exhaust steam and water side in order to equalize the heaters and to equally distribute the feedwater load. The feedwater flows by gravity from the two 30,000 gallon deaerator storage tanks to a group of four 1000 lb pressure feedwater pumps, with three operating for delivering water to the three high pressure boilers. The feedwater from these pumps passes through a horizontal tubular heater in which steam at 225 lb pressure is utilized to raise the feedwater temperature to 350 F. The condensate from this heater is controlled by a flow control valve and is delivered to the feedwater system in the feedwater inlet of the deaerators. The feedwater after leaving the high pressure pumps is delivered to the rear steam drum of each high pressure boiler, passing through the feedwater sprays of the steam scrubber and then to the boiler circulating system.

In addition to the lime-soda treatment in the hot process tank, an auxiliary treatment of sodium hexametaphosphate is used for further conditioning the feedwater for the high and low pressure boilers. The phosphate is pumped intermittently into the feed pump discharge lines to the low pressure boilers. The phosphate for the high pressure boilers is pumped continuously and independently to each high pressure boiler by a group of four variable capacity chemical feed pumps with three operating. Each pump has a maximum capacity of 9.8 gallons per hour, with a minimum capacity of .98 gallons per hour, and the phosphate in the water solution is pumped to the bottom drum of the high pressure boilers through a stainless steel pipe which extends 36 in. into the mud drum. About 270 lb of phosphate is delivered to the high pressure boilers daily and .013 lb of phosphate is used per 1000 lb of water. The phosphate concentration in the boiler water is maintained between 40 and 50 ppm. The total cost of chemical treatment for the high pressure boilers amounts to approximately $.003 per 1000 lb of water treated.

Tabulation A gives the chemical analysis of raw water, treated water as it leaves the filters, and the high pressure boiler water.

The hardness in the treated water is maintained between .5 and .8 grains per gallon and is controlled to give a low sludge in the boiler water. The control of the treatment of the boiler feedwater and the control of the concentration of the boiler water in the high pressure boilers are all under the direct supervision of the filter operator. The amount of blowdown is definitely controlled by the chemical analysis and is set by the filter operator to maintain the desired conditions in the boiler water.

In the testing of the boiler water, the conventional test is made for controlling soda ash and lime along with tests for hardness. The boiler water is tested for alkalinity, sulphates, chlorides, and phosphates. This is routine testing and as previously stated, these tests are made every two hours.

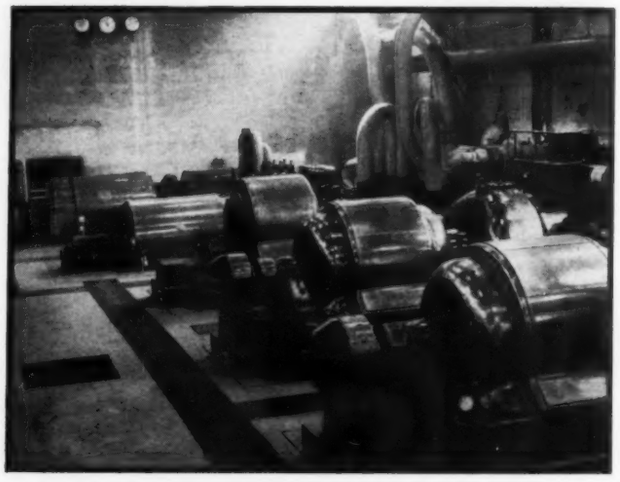


Figure 4 — General view of the power house, with high pressure units in the background.

It can be readily seen that the equipment used in this plant for treating the feedwater for a group of high pressure boilers is conventional feedwater equipment with no complicated methods of handling feedwater and requires a minimum of supervision.

OPERATING EXPERIENCE WITH THE HIGH PRESSURE BOILERS

High pressure boilers No. 1 and 2 have been operated since June 1936, or a period of somewhat over seven years, and No. 3 boiler has been operated since December 1940, or somewhat over 2½ years. The average steaming conditions of the high pressure boilers are 850 psi pressure, 830 to 840 F total steam temperature.

Our experience in operating this high pressure plant has been most satisfactory. At no time have we lost any boiler heating surface due to scale deposits in the tubes or heating surfaces. When the original plant was installed boilers were taken off for internal inspection every 30 days. This operating period was soon increased and for the past several years the average operating time between inspection periods has been 100 days. Approximately four days are required to clean up a

boiler and take care of the necessary repairs to auxiliary equipment. The major part of this time is required for external cleaning. When the boilers are off the line the drums are washed out and the tubes in the furnace water walls and the first bank of boiler tubes are given a turbine cleaning. The deposits in the boilers after a 100 day operating period consist of a white powdered coating in the drums and a maximum deposit of approximately .020 in. thickness in the tubes.

The availability of these boilers is as follows:

For the year 1942

No. 1 boiler . . . . . 95.0 per cent
No. 2 boiler . . . . . 95.7 per cent
No. 3 boiler . . . . . 96.0 per cent

For January through July inclusive, 1943

No. 1 boiler . . . . . 94.5 per cent
No. 2 boiler . . . . . 96.5 per cent
No. 3 boiler . . . . . 95.6 per cent

It is evident, therefore, that these boilers have an availability between 95 and 96 per cent. This availability compares in our opinion vary favorably with a low pressure boiler plant. The high pressure plant feedwater heater requires cleaning every 60 days. This heater is cleaned with a four per cent inhibited hydrochloric acid solution. This solution consists of 14 lb of an inhibitor, 632 lb of 20 degree Baume hydrochloric acid and 4400 lb of water. The inhibited acid solution is circulated through the closed heater by means of a centrifugal acid pump with a capacity of 110 gallons per minute at 30 ft head. The temperature during the cleaning period is maintained between 140 and 150 F, as higher temperatures cause the inhibitor to break down. The time of cleaning depends upon the quantity and nature of the deposits to be removed but usually 30 to 40 minutes cleaning time is sufficient. During this cleaning period frequent tests are made on the inhibited acid solution and if necessary fresh acid is added to maintain the original designated strength of the solution.

Immediately following the acid cleaning, a treated water containing approximately 10 to 15 lb of soda ash per 100 gallons is circulated through the equipment to neutralize the last remaining traces of acid. Following this step the heater equipment is flushed thoroughly with water.

TABULATION A

	Raw water	Treated water
pH value	6.1	9.8
	ppm	ppm
Hydroxide (OH)	0	2
Carbonate (CO_3)	0	30
Bicarbonate (HCO_3)	12	0
Sulphate (SO_4)	93	83
Chloride (Cl)	12	11
Silica (SiO_2)	9	....
Calcium (Ca)	22	....
Magnesium (Mg)	3	....
Soap hardness ($CaCO_3$)	67	12
Suspended solids — estimated	6–8	4–6
Organic (by ether extraction)	11	....

	Boiler water, ppm
Phosphate-alkalimetric (PO_4)	33
Phosphate-gauge (PO_4)	25
Sulphate (SO_4)	600
Chloride (Cl)	76
Dissolved silica (SiO_2)	37
Aluminum (Al)	neg.
Total solids	1500

Water white, slightly turbid, low sludge.

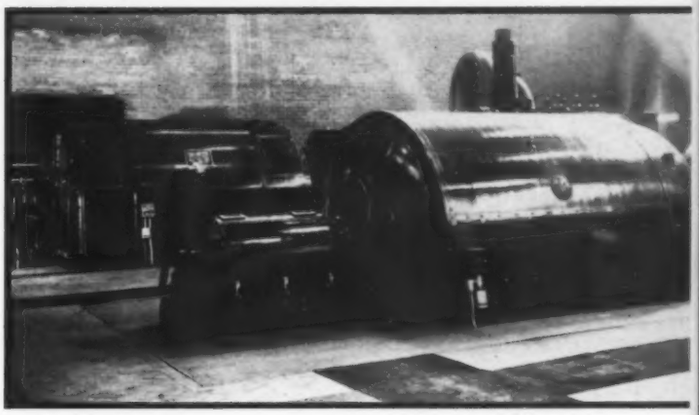


Figure 5 — Close-up of two 10,000 kw topping turbo-generator units.

OPERATING EXPERIENCE WITH TOPPING TURBINES

Practically all of the high pressure steam produced in the three boilers is used for generating power in two 12,500 kva, 10,000 kw turbo generators. These generators take steam at 800 psi, 800 F and exhaust into the 225 lb steam system at 225 lb pressure, 540 F. Both generators are normally loaded to a high production rate and over a monthly period the power production on these two generators averages from 13 to 14 million kwhr, or an average generating rate of 18,000 to 19,500 kw with the two generators. The first generator, installed in 1936 and designated as No. 6, and the second generator, installed in 1940 and designated as No. 7, are both operated at a speed of 3600 rpm. The No. 6 unit was first operated on June 16, 1936 and operated until February 28, 1937, without any interruptions for washouts and with a total of 120 hours interruption for minor repairs. On this date the turbine was given the first experimental washout.

Tabulation B shows the availability due to turbine washouts as well as other information concerning continuous operation. All of this data is computed up to August 1, 1943.

It will be noted that the total availability of this turbo generator is 97.9 per cent and the availability from a washout standpoint only amounts to 99.39 per cent. Fewer washouts have been necessary in 1943 and the washout period for this year is 120 days as compared with 60 days in previous years. This lengthening of periods between washouts is due to both an improved method of washing out and the installation of the feedwater sprays in the steam scrubber of No. 3

high pressure boiler. Since this turbine was installed in 1936, it has been operated 61,111 hours and generated a total of 596,115,000 kwhr. Based on operating hours, this is an average generating rate of 9760 kw for this seven-year period.

The No. 7 generator, which was started in operation in December 1940, is also a 10,000 kw, 80 per cent power factor unit operating at 3600 rpm and under the same throttle and steam conditions as No. 6. This turbine has not been washed out up to the present time. It is designed with a second reaction stage by-pass valve which makes possible the admission of high pressure, high temperature steam to the exhaust end of the turbine. This valve is operated on each eight-hour turn and in our judgment has been of considerable help in preventing excessive deposit formations on the turbine blading. At the present time, however, indications show that deposits are forming on the blades of this turbine and in the near future we believe a washout will be necessary. This is indicated by the following operating readings:

Date	3–25–41	8–17–43
Inlet pressure, psi	830	830
Inlet temperature, F	830	810
Exhaust pressure, psi	225	225
Exhaust temperature, F	560	555
Kw output	12,000	10,800
Power factor	1.00	1.00

This unit has operated 22,294 hours out of a total of 22,704 installed hours giving an availability of 98.2 per cent. All shutdowns have been for repairs. During this operating period 184,154,000 kw have been generated, or an average of 8260 kw during the operating hours. The lower productive rate on this turbine as compared with No. 6 is due to the method of loading the two generators. The No. 6 is loaded to capacity as a base load unit and the No. 7 generator for a larger portion of the time has been used for back-pressure control taking the swings in load as required.

WASHING PROCEDURE

It may be of interest in discussing feedwater treatment to give a brief outline of the procedure in washing the No. 6 topping turbine. When this machine was originally installed it was noted over a period of time that the output of the unit was gradually decreasing. From changes in pressure observed throughout the turbine it was evident that deposit was forming on the buckets thus reducing the available capacity and efficiency of the unit. No standard method of washing the deposits from the turbine buckets was available and therefore various methods were tried out over a period of time. The first washout was made on February 28, 1937.

At the time of this first washout the unit had been in continuous operation since installation except for shutdowns to make minor repairs which totalled 120 hours. The output had dropped to 8700 kw. The routine of washing at this time consisted of gradually reducing the load to 3000 kw by means of closing the main inlet high pressure steam valve until this condition was reached, then completely opening all of the control valves. Water was admitted to the expansion bend leading to the automatic stop valve by means of a connection from the 900 lb boiler feedwater line. This water was gradually admitted, decreasing the steam to 480 F total temperature. No records were kept of this washout except as stated above.

Numerous methods have been tried out, of which the following is the latest and most satisfactory to date:

A 2 in. connection from our 225 lb steam system was connected into a high pressure tee, which is used as a mixer. Into this mixer is connected a 1 in. water line, which is controlled by a regulating needle valve. This mixer is located between the main turbine inlet header valve and the automatic stop valve. With throttling valves properly placed, the steam driving the unit can be regulated and changed from high pressure to low pressure or from low pressure to high pressure as the case may be. The water is supplied from the boiler feed line with the pressure being regulated by bleeding the line which also keeps the washout water at a desired temperature. A recording thermometer is connected into

TABULATION B

Year	Installed hours	Operating hours	Number of washouts	Washout hours	Washout per cent availability	Repair hours	Repair per cent availability	Total hours off	Total per cent availability
1936	4752	4683	..	..	100.00	69	98.55	69	98.55
1937	8760	8607	6	49	99.44	104	98.82	153	98.46
1938	8760	8277	6	59	99.33	424	95.16	483	94.49
1939	8760	8651	6	56	99.36	53	99.40	109	98.76
1940	8784	8673	6	55	99.37	56	99.37	111	98.74
1941	8760	8588	7	73	99.17	99	98.87	172	98.04
1942	8760	8621	6	68	99.22	71	99.19	139	98.42
1943	5088	5011	2	25	99.51	52	98.98	77	98.49
Total	62424	61111	39	385	99.39	928	98.52	1313	97.90

The two washouts during 1943 were made on January 30 and May 30.

TABULATION C — Turbine Washout Data

Time	Inlet steam		Exhaust steam	Water		Rpm
	Pressure	Temperature	Temperature	Pressure	Temperature	
10:35	40	675	500	175	200	300
11:15	45	580	480	175	200	475
1:00	45	400	450	175	205	600
2:30	70	265	260	160	200	700
3:00	84	265	230	160	200	350
3:40	95	265	235	160	205	400
4:40	95	265	240	160	205	450

The following readings were taken before and after completing the washout of May 30, 1943.

	Before	*After*		*Before*	*After*
Initial steam pressure, psi	830	830	Diff	76	45
Initial steam temperature, F	820	845	Kw	10,100	13,600
Exhaust pressure, psi	215	215	A-c amperes	830	1,130
Exhaust temperature, F	580	595	A-c volts	6,825	6,900
First stage pressure, psi	755	720	D-c amperes	230	255
Fifth stage pressure, psi	495	428	D-c volts	67	80
Ninth stage pressure, psi	291	260	Power factor	1.00	1.00
			Generator temperature	64 C	64 C

the header line just ahead of the automatic stop valve with numerous pressure and temperature instruments placed as necessary.

Thus after the machine has been taken out of service and the steam shut off by means of the main inlet high pressure valve, the machine begins to slow down. The motor operated exhaust valve is closed as the 6 in. atmosphere valve is opened. When washing out these turbines the exhaust steam from the washing operation is discharged to the atmosphere by a 6 in. vent line in order to prevent the washed out deposits from contaminating the 225 lb low pressure steam system. The machine is allowed to drop to a speed not under 300 rpm. This speed is maintained by means of a 1 in. by-pass valve on the main inlet high pressure valve. This steam has a temperature of about 800 F. The machine is kept running in this manner with all of the control valves wide open and all drain valves closed.

As soon as the inlet temperature at the throttle settles down and starts to level out, all temperatures and pressures are carefully observed and the low pressure steam at a temperature of approximately 540 F is slowly admitted to the aforementioned mixer, mixing with the high temperature steam and gradually decreasing the inlet steam temperature by increasing the admission of low pressure steam and decreasing the admission of high pressure steam through the by-pass valve. This procedure consumed from 12 to 14 hours.

After all of the high pressure steam has been shut off and the inlet steam temperature levels off at the normal temperature of the low pressure steam, water is gradually admitted to the mixer, regulated by the needle valve until the saturation point is reached, which is normally about 265 F. The unit is run under this saturated condition for about two and one-half to three hours thus permitting a thorough washing.

Following this run the water is gradually shut off reversing the above procedure. After all of the water is shut off and the temperature begins to level out, the high pressure, high temperature steam is slowly admitted to the expansion bend, mixing with the low pressure steam and increasing the temperature. The high pressure steam is increased and the low pressure steam decreased until the maximum temperature is reached under such conditions.

Following inspection and assurance of the moisture all being eliminated from the turbine and turbine drains, the control valves are gradually closed allowing a full head of steam to be attained in the header line, after which the motor operated valve is opened. Following this the turbine is properly brought up to speed and put back in service.

During this washout procedure every possible precaution is taken to keep the inlet temperature decreasing or increasing as the case may be at the rate of approximately 100 F per hour, by regulating the mixture of steam and water as necessary and at the same time maintaining a speed between 300 and 1000 rpm.

During our last washout on May 30, 1943, samples of the discharge water were taken as an experiment, but not analyzed until after the completion of the washout. The following are the results disclosed:

	Start	Midway	Finish
Silica	184.0 ppm	88.3 ppm	25.5 ppm
Iron and aluminum oxide	24.5 ppm	53.0 ppm	175.0 ppm
Calcium oxide	8.8 ppm	15.0 ppm	12.5 ppm
Magnesium oxide	3.3 ppm	4.3 ppm	2.2 ppm
Total solids	808.8 ppm	598.0 ppm	207.0 ppm

Total solids on washout water approximately 150-200 ppm.

Tabulation C gives data obtained during the washout of May 30, 1943.

In conclusion, we would state that the operation of both the high pressure boilers and high pressure topping generators has been most satisfactory both from an operating and maintenance standpoint. In general we

have had little more difficulty in operating a high pressure plant at 800 lb, 800 F than in operating the low pressure plant at 225 lb, 500 F temperature. Supervision and control of feedwater are the most important factors in obtaining satisfactory operation of this plant

DISCUSSION

PRESENTED BY

J. B. ROMER, Chief Chemist, The Babcock and Wilcox Company, Barberton, Ohio

J. H. STRASSBURGER, Manager, Department of Service and Maintenance, Weirton Steel Company, Weirton, West Virginia

C. E. JOOS, Cochrane Corporation, Philadelphia, Pennsylvania

H. L. BAER, President, Water Treatment Company of America, Pittsburgh, Pennsylvania

A. J. DOTTERWEICH, District Sales Engineer, Permutit Company, Pittsburgh, Pennsylvania

J. B. Romer: I would like to congratulate Mr. Strassburger not only for an excellent paper but for his part in the development and operation of the 800 lb topping installation at Weirton.

As the author remarked in his opening paragraph, very few of the high pressure plants that were operating in 1935 used a high percentage of make-up, and I am quite sure that Weirton represents the first high pressure, large capacity, 100 per cent make-up plant. Today, there are a number of industrial power plants operating with 100 per cent make-up and at pressures much higher than at Weirton. These cases in no way detract from the record made at Weirton; instead, they emphasize the fact that Weirton built on a sound policy that could be followed or expanded.

Boiler feed water treatment is a subject that is ever in a state of flux, beginning with the early knowledge of the effect of heat on temporary and permanent hardness, through the early work on treatment with lime and soda to the present day methods whereby almost any type of raw water can be successfully treated to produce a suitable feed water.

Some of the modern installations involving combinations of treatments for specific reactions can produce a treated water that is comparable to that obtained by direct distillation.

The selection of a satisfactory water treating system involves full knowledge of available raw waters as well as a knowledge of the performance, operating characteristics and initial and operating costs if a suitable feed water is to be obtained at an economical cost.

Weirton's record of over seven years with an availability of 95-96 per cent without "at any time having lost any boiler heating surface due to scale deposits in the tubes or heating surfaces" and at a cost for chemical treatment of $3.00 per million pounds of water treated is indeed a worth-while accomplishment.

The selection of equipment ample for settling, and separation without loading "like the camel's back" has contributed to the yielding of returns in the form of long operating periods and short outages or in other words, high per cent availability.

Several conditions noted by the author are worthy of comment.

The adoption of continuous phosphate feeding instead of shot feeding is, in my opinion, a worth-while change, this is true irrespective of whether or not raising the feedwater temperature, as outlined by the author, necessitated the change. The lower excess phosphate in the boiler water is one of the advantages thus gained.

The hardness of the feedwater is an interesting point; some operators of high pressure boilers, where the feed is 100 per cent make-up, reduce the residual hardness to values of the order of 4-8 ppm as against 9-14 ppm as reported by Weirton.

I would like to ask Mr. Strassburger if he would advise us the percentage blowdown required to maintain the boiler water at the desired concentration.

Another question has to do with the acid cleaning of equipment. The paper states that the feedwater heater has been frequently and successfully cleaned with inhibited acid. I would like to inquire as to the extent that this method of cleaning has been applied to other power equipment.

At first glance, it might appear that the washing of No. 6 turbine was a considerable problem. The washout availability, as given in Table B, of 99.39 per cent for a period of over seven years, clearly indicates that turbine deposits are not a serious matter.

The history of No. 7 generator is sufficiently different than that of No. 6 to be of especial interest.

This unit has been in operation for nearly three years during which time it has not been washed; instead, high pressure, high temperature steam is admitted once every eight-hour turn to the exhaust end of the turbine.

The author states that the machine is about due for a washing. It will be interesting to observe the experiences of the first washing of No. 7 unit and the results will be of great interest to all concerned with turbine blade deposits.

In closing, I cannot do better than to quote the last sentence of the author's paper, "Supervision and control of feedwater are the most important factors in obtaining satisfactory operation of this plant."

J. H. Strassburger: In answer to Mr. Romer's questions, the percentage of blowdown required to maintain the boiler water at the desired concentration is about 10 per cent. We have not applied the acid cleaning to any other equipment.

C. E. Joos: Mr. Strassburger, in his presentation of the design and operating features of this plant, makes it clear that, while the problem of feedwater conditioning is rather difficult, it has been solved with relatively simple apparatus from the standpoint of design and operation, obtaining from that system excellent results in maintaining the availability of the boilers at a very high rate.

Anyone familiar with the Ohio River realizes that it fluctuates widely, not only in its chemical but physical characteristics; at some seasons of the year the water is quite clear, yet in others during the rainy season, particularly in the spring, the water is charged with

enormous quantities of suspended matter. Likewise, during these periods the water may vary widely in chemical composition.

The selection of the hot process softener for handling this condition has proven to be wise, and indicates considerable foresight in view of the fact that not many industrial installations were made utilizing 100 per cent make-up water at the time the plant was planned.

It is interesting to note that, in the extension of the power plant, practically all of the equipment was duplicated, substantiating the original selection.

While many improvements have been made in the hot process water softener from the standpoint of the apparatus, as well as the chemical treatment, this method of treatment involving lime and soda pretreatment with internal treatment of phosphate stands today as the most widely accepted and satisfactory for this type of service.

H. L. Baer: The paper by Mr. Strassburger is of considerable interest. I consider the Weirton boiler plant an outstanding job, and Mr. Strassburger's paper is most complete, both as to installation and operation.

The fact that the Weirton boiler plant uses 100 per cent make-up water for feed, makes it a difficult job.

I desire to comment on the fact that the feedwater entering the boilers contains from .5 to .8 grains per gallon hardness, and that phosphate is used to precipitate this hardness for the purpose of scale prevention.

The addition of phosphate tends to increase the total solids, and adds to the necessity of close chemical control to avoid carryover.

The spray steam scrubbers have proven their value, and under conditions found are indispensible. Yet the steam carries about .5 ppm dissolved solids and turbines require washing. I believe that further treatment will improve this condition and result in further efficiency.

Further treatment would consist of one of the organic treatments for balancing the boiler water to further reduce the amount of solids going over with the steam, and to completely prevent any of the solids from adhering to the boiler surfaces. Another effect of balancing with the latest organics is increased rapidity in the liberation of steam.

It would be interesting to see the effects of proper balancing on a job of this kind with proven organics.

A. J. Dotterweich: Mr. Strassburger is to be complimented on a very interesting and clearly presented paper. The success which he has had in the operation of this hot process plant is undoubtedly due in great part to the skill with which it was designed and operated. Everyone must agree with his final conclusion "Supervision and control of feedwater are the most important factors in obtaining satisfactory operation of this plant."

Mr. Strassburger mentions a number of factors of safety which he employed in adopting the design of the feedwater system as well as the high pressure boilers themselves. Amongst these factors of design may be mentioned:

a. The boilers were designed with oversized steam disengaging drums reducing the velocity of steam disengaging.
b. The boilers were equipped with large furnaces.
c. The boiler design has good circulation, avoiding hot spots.
d. Large heating surface is provided.
e. No economizer is used, eliminating corrosion and scaling problems in the economizer.
f. The hot process feedwater treating system was equipped with settling tanks of three hours detention or about three times the usual standard one hour employed elsewhere. No mention is made as to the filter area and so it is probable that the filters were also made of a size in keeping with the settling tank.

In order to utilize the information given in this paper and apply it for other feedwater problems on high pressure boilers, special conditions surrounding this installation should be noted:

a. The raw water is very low in alkalinity, being only about 10 ppm expressed as $CaCO_3$ and the sulphate content is high, being 137 ppm expressed as Na_2SO_4. This provides a natural high sulphate-carbonate ratio in this feedwater.
b. It is assumed that there are few low pressure turbines into which the topping turbines discharge.
c. It is assumed that there are very little returns and short return lines.
d. There is no economizer present.

Although the paper expresses entire satisfaction with the existing treatment, there are undoubtedly a number of limitations which would be experienced as operating difficulties if the same type of treatment were applied under other conditions, and the special conditions above described did not exist. These limitations are as follows:

a. The hardness of the treated water is 8 to 12 ppm expressed as $CaCO_3$, which is equivalent to 0.5 to 0.8 grains per gallon. This is a low hardness for hot lime soda treatment and it is obtained at the expense of considerable excess soda ash. The treated water analysis discloses an excess soda ash of almost 3 grains per gallon. This raw water has so low an alkalinity as above mentioned and so high a non-carbonate hardness, that it is not a water that is usually treated by hot lime-soda because hot lime-soda is predominantly applied for waters high in carbonate hardness where the lime treatment would reduce this carbonate hardness and thus reduce total solids. In this case, the excess soda ash increases the total solids by increasing the alkalinity expressed as $CaCO_3$ from 10 ppm in the raw water up to about 60 ppm in the treated water, which is a 50 ppm increase. This necessarily increases boiler blowdown. It is to be noted that the lime-soda treatment is mostly soda ash treatment because 135 ppm of soda ash is added and only 38 ppm of lime.
b. The excess soda ash decomposes in the boiler to form free CO_2 in the steam. We calculate that about 27 ppm of free CO_2 would be generated from the treated water analysis given in Tabulation A. This means that the steam must be low in pH value which usually gives trouble by corrosion in return lines. Perhaps there are few return lines in this plant so that this possible difficulty has not been experienced.
c. Some hold the theory that free CO_2 in the steam may promote adherent turbine deposits, especially in low pressure stages. Such adherent turbine deposits are not easily removed by washing with saturated steam as has been successful in this case in the

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TABLE A CORRECTED

	Raw	Treated	Boiler water
Total hardness as $CaCO_3$	67	12	....
Ca as $CaCO_3$	55	...	....
Mg as $CaCO_3$	12	...	....
Alk A as $CaCO_3$	10	62	....
Alk B as $CaCO_3$	0	22	....
Alk C as $CaCO_3$	0	0	....
PO_4	0	0	33
NaCl	20	if 20	125
Na_2SO_4	137	if 137	890
SiO_2	9	if 6	37
Total solids (calculated)	176	221	1500

CO_2 in steam: from 44 carbonates as $CaCO_3$, 0.35 x 44 = 15
18 bicarbonates as $CaCO_3$, 0.7 x 18 = 12
27 ppm

topping turbines. If the exhaust of the topping turbines had gone into large low pressure turbines, possibly more trouble would have been experienced by adherent silica turbine deposits which would be difficult to remove unless a caustic soda wash were employed. It is to be noted that the turbine deposits contained mostly silica, judging from the analysis of the turbine wash drainage liquor. Possibly also in this case, the naturally high sulphate-carbonate ratio may have prevented the deposits from being more adherent. Professor Straub of the University of Illinois has developed the theory that high sulphate-carbonate ratio is instrumental in preventing adherent deposits in high pressure turbines.

d. The residual hardness in the treated water causes after-reactions in the feedwater system when the temperature is raised. This is exemplified by the difficulty described by Mr. Strassburger with the blowdown heat exchangers which were abandoned because of such deposits and replaced by flash tanks. Furthermore, the difficulty is exemplified by the troubles with deposits in the closed heater which have to be removed by acid treatment occasionally

The original hot lime-soda plant was installed when the boiler pressure was low. When the boiler pressure was raised, the existing hot lime-soda plant was extended. There may have been good reasons why this decision was made. However, to round out the consideration of the general subject of feedwater treatment as applied to this character of water, it may be useful to consider the possible results if zeolite treatment were used.

a. With zeolite treatment the residual hardness would be only 0 to 2 ppm instead of 8 to 12 ppm. Therefore, there would be less phosphate required in the secondary boiler treatment and therefore less sludge produced in the boiler.

b. The alkalinity of the treated water could be kept as low as desired and therefore there would be lower CO_2 in the steam and less return line corrosion.

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WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

EAST PITTSBURGH, PENNSYLVANIA

▲ IN keeping with the trend toward the ever increasing size of things, steel mills have grown until some of them require electric power supplies that would be suitable for a medium sized city. Such concentrations of power present problems that are usually considered only in the category of the utility central station system. Most steel mills generate sizable blocks of power in their own plants besides being frequently tied in with a local utility, either for supplementary or stand-by service.

The distribution of this power to the various points in the mill, requires and receives serious consideration from the standpoint of economy and continuity of service. The last mentioned is always forcing itself into the limelight since to date there have been no certain means of preventing faults on power systems. To be sure great strides have been made in the improvement of the quality of apparatus and power transmission means, so that very few faults are due to their failure. They occur nevertheless and must be coped with.

Modern relays, properly applied to a well designed distribution system can go a long way toward minimizing the effect of faults on the continuity of the power supply to various loads in the mill.

There are many types of distribution systems but they consists of one or more of the following fundamental types of transmission lines:

(a) Radial
(b) Parallel
(c) Loop
(d) Tapped
(e) Buses

The application of relays to protect each of these types involves a different analysis in each case and usually a different type of relay. The classification of some of these relays is as follows:

(a) Overcurrent
(b) Power directional overcurrent
(c) Impedance measuring
(d) Differential
(e) Pilot wire

These can be put into two main groups of "high" and "slow" speed relays. "High speed" refers to relays operating on the order of one to three cycles and "slow speed" from six cycles up. There are also other classifications that can be made, such as phase relays and ground relays.

The proper application and choice of the correct relay for any type of line can follow no set rule, but each case requires careful analysis. The following usually has to be taken into consideration:

(a) Minimum fault currents

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(b) Maximum fault currents
(c) When the system is grounded, both phase and ground currents in (a) and (b)
(d) Voltages, both phase and ground

Where these values cannot be readily calculated, valuable time can be saved by making use of both the a-c and d-c calculating boards.

Each of the types of systems listed will now be briefly analyzed, and one or more of the types of relays most suitable to the various systems will be discussed. Later it will be shown how these types of power transmission circuits may be combined to form the distribution system in a large steel mill.

RADIAL LINE

The radial line while being simple in appearance can in some cases become quite involved when selectivity of tripping under fault conditions is attempted. In Figure 1, showing a typical radial system, consider a fault located in the most remote section at point C. Certainly there is no reason why breaker C should not open as fast as possible and therefore an instantaneous or one-cycle overcurrent relay can be applied. Care must be taken in choosing the current setting of this relay to make sure it is high enough to allow starting of motors without tripping. Relays protecting breakers A and B must necessarily be set for a longer time than C and therefore must be of the induction or time delay overcurrent type. The tripping time for either of these relays depends on the number of breakers between it and the most remote line section and the time allowed for each breaker to open. The difference between adjacent relay time settings should be the time required for a breaker to trip after its trip coil has been energized plus a reasonable safety margin. Most modern breakers have an operating time of 8 cycles but in order to be assured of selectivity and to allow for some relay over-travel after being de-energized, the time margin between adjacent relays is generally increased to at least 15 cycles or ¼ of a second under maximum short circuit conditions. If the breakers are old they may have a longer tripping time and therefore a larger time increment must be used in setting relays. The same rules apply for ground as for phase relays with the exception that the ground relays can be given a more sensitive pick-up setting since they are normally not subjected to load currents.

PARALLEL LINES

There have been many methods of relaying advanced and used for the protection of parallel lines but only the more common schemes will be discussed. First consider a set of parallel lines as in Figure 2 with a power source at one end and a load substation at the other. Any pair of lines such as this can be protected with time delay overcurrent relays at the power station end and directional overcurrent relays at the substation end. When a fault is near the power station, the breaker connected to the line in trouble trips first. Until this breaker opens there is practically no current flowing through the other breakers. After it has tripped however the other three breakers carry the same current. The directional relays at the substation end allow only the breaker connected to the faulted line to trip. It is evident that the time delay overcurrent relays at the power source end must have sufficient time delay to time over the directional relays at the substation end. For this particular case, directional relays at the substation can be practically instantaneous.

If there were several sets of these parallel lines in series, each set would add one breaker's time to the setting of the power source relays. The result would be

Figure 1 — Radial lines.

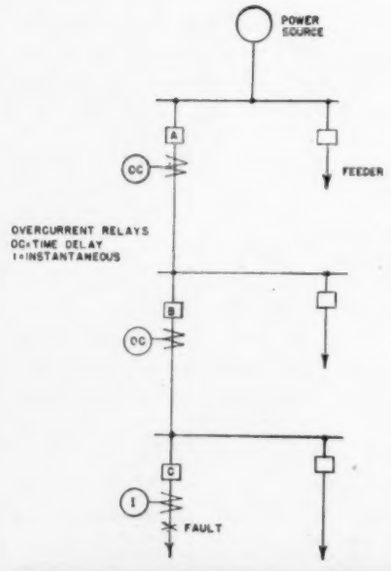


Figure 2 — Parallel lines.

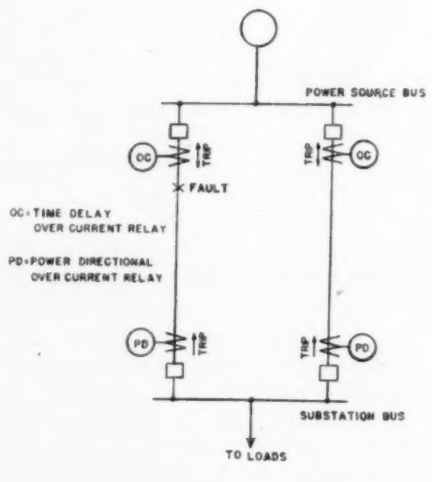
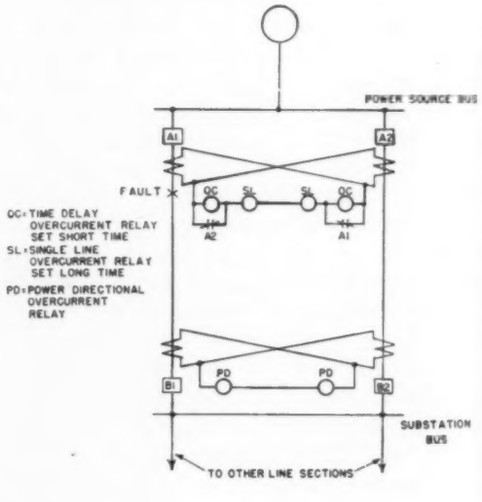


Figure 3 — Parallel lines, differentially connected transformers.



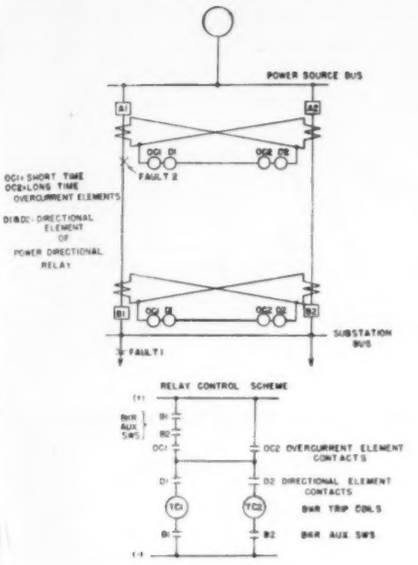


Figure 4 — High-low differential scheme.

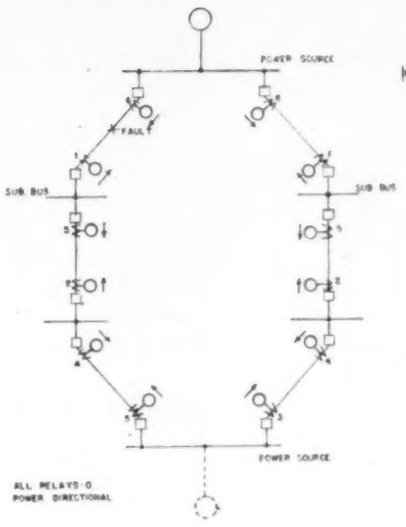


Figure 5 — Loop system.

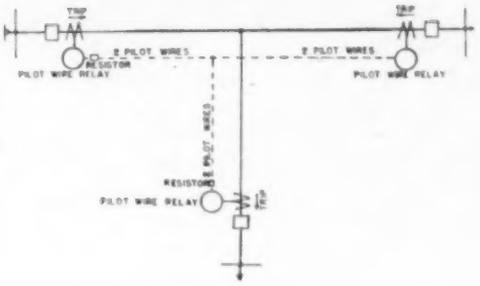


Figure 6 — Tapped line pilot wire relay protection.

an objectionable long time in clearing faults near the source of power.

This time can be eliminated by using differentially connected transformers as shown in Figure 3. Fault currents passing through any parallel line section will result in no current in the relays and therefore they need not be time coordinated with those in other line sections.

In the faulted line section this differential scheme functions sequentially similar to the scheme just described. It is necessary after the opening of one power source breaker to block the tripping function of the other line relay and substitute for it a relay that has the proper time setting for single line operation.

Where there is a power source at both ends of a parallel line section, directional relays must be used with all breakers. The so-called "high-low" scheme shown in Figure 4 can be used for this. Only the usual number of relays are used, i.e. one set for each line terminal. This scheme makes it possible to maintain the short time characteristic of the differential scheme just described and also the longer time required for single line operation. This is accomplished by using the two relays for like phases at the end of a parallel section as a pair, one being set for a short time and the other for a long time. Each relay can trip either breaker by depending on the directional contacts for proper selection in the case of the short time relay. Suitable breaker auxiliary switches open the trip circuit of the "short time" overcurrent element for single line operation.

There are other methods of protecting parallel lines, such as the use of balanced current relays and pilot wire relays. The balanced current scheme requires a power source on the bus on the end of the lines which they protect, in order to get an unbalance in current for proper fault selection. Supplemental relays (sometimes of the directional type) must be provided for single line operation. The pilot wire relay is probably the most adequate type for parallel line protection in that it will function only for faults within the faulted line section. Since this type of relay can be used in most any type of system and has so many advantages over other relays when distances are short, it will be discussed in more detail later.

THE LOOP SYSTEM

This type of system consists of a series of substations connected with transmission lines, the combination forming a loop that starts and ends at the generating station. Figure 5 illustrates this type of system. Power directional relays are sometimes used for the protection of systems of this type but the long tripping time makes them objectionable. Each line section beginning at the power source adds an increment of time (a minimum of ¼ second) to the tripping time of the power source breaker. In the system here illustrated with 6 line sections the minimum time in which the breaker at the power plant could be tripped would be 1.5 seconds. A fault allowed to remain on the system this length of time would certainly cause synchronous motors to fall out of step.

Where two or more power sources feed a loop, satisfactory timing cannot be obtained with directional overcurrent relays. High speed impedance type relays, directionally controlled, are generally used for protection of a system of this nature provided there is at least 5 per cent impedance drop in each line section under minimum fault conditions. Their ability to measure the impedance to the fault up to 90 per cent of the line length gives fast relaying for phase faults.

Usually the length of the lines in a steel mill system is too short to permit their use, except in unusual cases. Where the lines are too short for impedance relays the pilot wire relay is ideal both for phase and ground

faults. It will protect the full length of a line section and give equally fast operation for any type of fault at any point in the line section. This type of relay will be discussed more in detail later.

TAPPED LINES

Frequently it becomes expedient to tap a line without the benefit of a breaker at the point of tapping. This gives the equivalent of three lines forming a wye (see Figure 6). A fault anywhere on the three lines should cause the three terminal breakers to open. It is very probable that the lines will be of unequal distances from the tapped point, which makes it impossible to obtain best protection with impedance relays. Also directional overcurrent relays are inadequate due to the necessity of time discrimination with other parts of the system. Here again the pilot wire relay can readily be applied and adequate clearing of faults on all three lines expected. Tapped lines can take many variations and while becoming more prevalent due to war-time restrictions, they are not popular with the engineers who have to work out their protection. A very complete discussion of this subject has been written by Messrs. Harder and Bostwick in A. I. E. E. Paper 43-118 dated May 1943 under the subject of "Relay Protection of Tapped Transmission Lines."

BUSES

Prior to the last ten years very little consideration was given to bus protection. The thought has always been that buses were so well constructed that faults would be a remote possibility. However, bus failures have occurred, resulting in damage and objectionable outages.

The present practice is to provide bus protection in one form or another. The most popular method is differential protection of the bus. This involves summing up all the current entering and leaving a bus structure in a manner shown in Figure 7. Normally all the current entering a bus leaves on some of the other circuits, the vector-sum of all currents being zero. The coil of the differential relay is connected in the path of this vector-sum current as totalized in the current transformer secondary circuits. In case of an internal or bus fault, all the current goes through the relay causing all breakers to be tripped.

In the application of bus differential relaying it is just as essential to guard against false tripping on through faults as it is to obtain tripping on internal faults. At normal load currents the differential current going through the relay operating coil is zero, but on heavy external faults it is possible for the relay to get appreciable current due to unequal saturation of current transformers, and differences in current transformer characteristics.

In order to minimize the effect of this, restraint coils are provided on the relay which produce a torque opposite to that of the operating coil. These restraint windings are connected in series with the current transformer secondaries of various incoming and outgoing lines. The restraints are in pairs, i.e. two on each restraint torque element of which there are three in the relay. On internal faults these restraints either cancel each other or are reduced by being on circuits with a small amount of back feed current, so that the operating coil torque can easily overcome them and give adequate protection. On through faults these restraints are at a maximum, making it possible for the operating coil circuit to receive an appreciable amount of differential current, caused by current transformer errors, without tripping.

There are other forms of bus protection such as the "fault bus" and linear coupler that have their place and do a fine job, but in general the scheme just described is the most prevalent so far in steel mills as well as in other power systems.

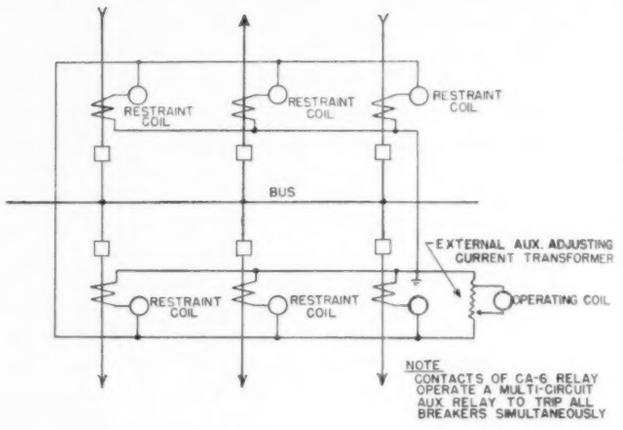


Figure 7 — Bus protection, using differential relay and summing up all currents entering and leaving the bus structure.

THE PILOT WIRE RELAY

Since this relay has been mentioned as a logical one to be applied for protection of parallel, looped and tapped lines, where the distances are in the order found in steel mills, it seems proper to describe it more in detail.

Figure 8 is a schematic diagram of the modern pilot wire scheme used. The relay is a single element device, yet functions on any type fault whether between phases or phase to ground. This is accomplished by carrying all three phase currents into a network contained within the relay case, and taking out a proportional single phase current to operate the relay element. The network is termed a "positive and weighted zero sequence filter" and consists of three coils wound on a common iron core plus two resistors. Between the filter and the operating element is a saturating transformer which limits the magnitude of the fault current that actuates the moving element.

This moving element has both an operating and a restraint coil. As can be seen from the diagram, the restraint coil is in series with the operating coil for local currents but for currents going over the pilot wire only

the restraint coil is encountered. A step-up insulating transformer is interposed between the relay and the pilot wires which relieves the relay element of insulation stresses due to longitudinally induced voltages in the pilot wire circuit and also permits the use of small size pilot wires such as No. 19 and in many short runs No. 22 telephone wire can be used.

A line section protected by pilot wire relays of this type has one relay as just described located at each terminal. They are connected with polarities so that current going through the line section will cause a circulating current over the pilot wires. This circulating current, which is proportional to the load current, goes through the restraint windings of each relay element and prevents false operation. On through faults this action

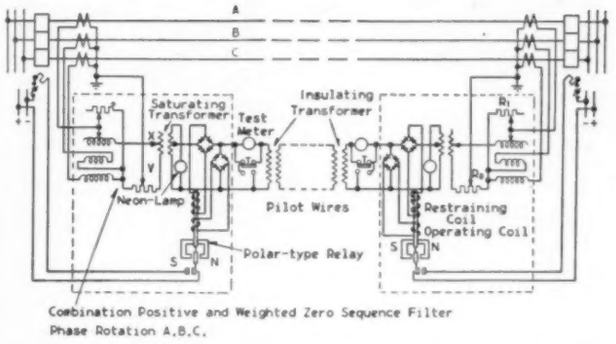


Figure 8 — Schematic diagram of modern pilot wire scheme.

is very definite and therefore there is no need for coordination with other relays from a time or current discrimination standpoint.

Internal fault can be considered in three classes:

1. Equal currents entering both terminals.
2. Unequal currents entering the two terminals.
3. All current entering one terminal and none entering the other.

These can be either ground or phase faults. In the first class the voltages produced by the fault current at each pilot wire terminal are in phase opposition or bucking and therefore no current goes over the pilot wire. The operating coil of each relay receives the fault current at its end and trips that breaker. Both terminal breakers are tripped at the same time.

In the second class there will be a difference in voltage between the ends of the pilot wires and current will flow over them. This current will be from the end that has the highest fault current and the effect will be to make the currents in the operating coils of the two relays equal. This will produce simultaneous tripping of both terminal breakers.

The third class of fault with current entering only one end of the faulted section, gives the same results. There being a voltage source only at one terminal, the current divides and goes over the pilot wire to the dead end and energizes the operating coil of that relay as well as its own. If the resistance of the pilot wires is neglected, it can be assumed that both relays receive the same current and therefore will trip simultaneously.

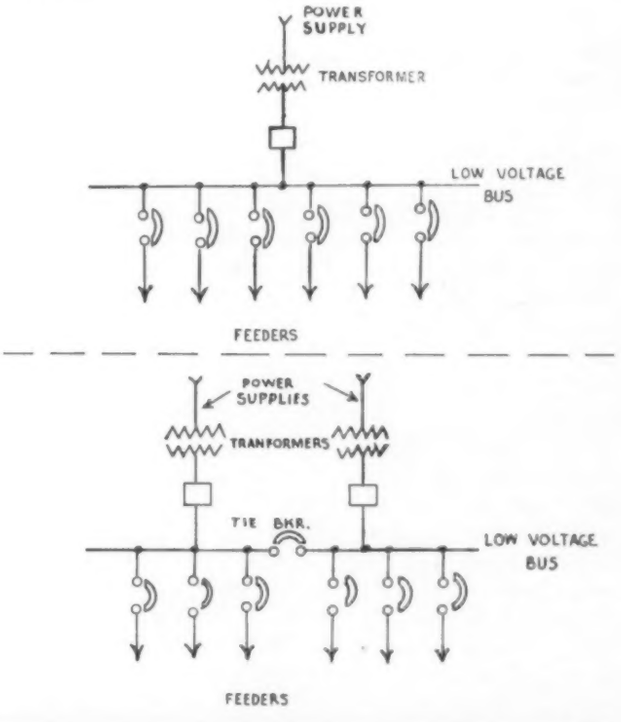
Since each relay receives only half of the fault current, its setting should be on the basis of half of the total minimum fault current entering the line section. On some systems this might take the setting of the relay near the load current value, but even if it does, the restraint on through load will prevent any false operation.

An open or broken pilot wire does not make this scheme inoperative, but it does prevent the two relays from dividing the fault current equally. Under such a condition each relay acts as an overcurrent device and will trip on local currents above its setting.

When a three-terminal line is being protected, a relay at each of the three terminals is required. The pilot wires are connected at a common junction. The resistance of each leg of the pilot wire circuit must be equal. Where the branches of the pilot wire run are unequal resistors are added as required to equalize the resistance of each branch. The relay fault current divides into three equal parts for this scheme and this trips all three breakers simultaneously.

This relay operates in one cycle on fault currents above twice its setting. It is therefore ideal on lines where it is desired to clear faults quickly in order to maintain stability between systems, and to give synchronous motors the best chance of staying in step or pulling back into step. It will be found that an installation using this type of relay will go a long way toward obtaining accurate fault segregation and simplification in determining relay settings.

Figure 9 — Diagram of connections in typical low-voltage system.



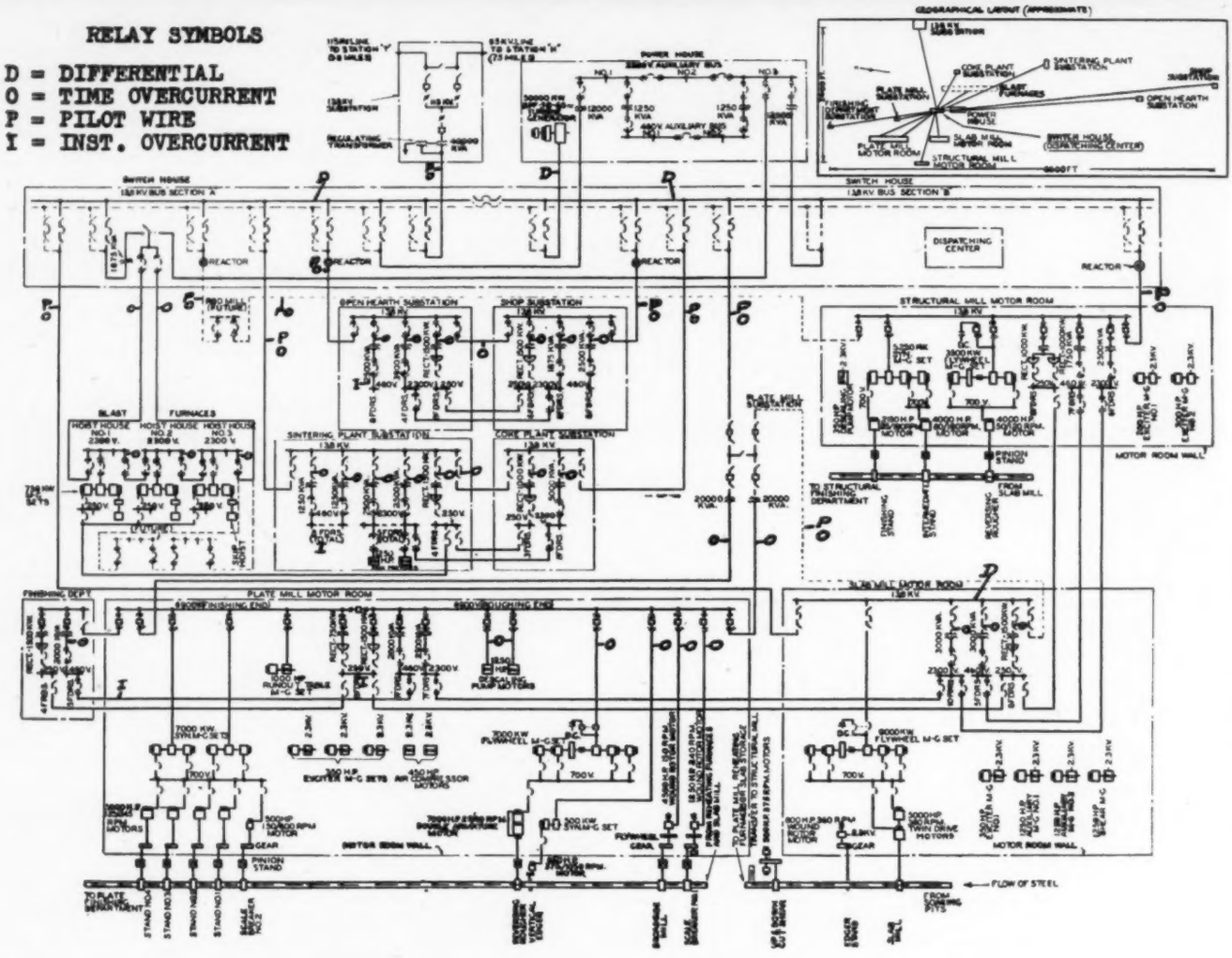


Figure 10 — Modern steel plant distribution system with types and locations of relays marked.

LOW VOLTAGE CIRCUITS — 460 VOLTS

Usually the breakers on low voltage circuits are the air variety and are frequently equipped with internal trip devices, which function very quickly to trip on the occurrence of faults. Frequently such circuits are fed through one or two transformer banks, so that faults are not reflected to any great extent to the high tension distribution system. When this is the case discrimination between faulted lines can usually be confined to the low tension side. Most 460 volt systems consist of a number of feeders backed-up by a group breaker. Sometimes there is an emergency tie to some other 460 volt bus but this is normally open (see Figure 9).

To obtain selectivity on faults certainly the group breaker must have sufficient time delay to allow any faulted feeder breaker to open. Induction overcurrent relays can generally serve this purpose. Care should be taken however that the breakers have a rating based on the expected time delay required before tripping. The feeder breakers can have instantaneous inherent trip devices which will allow choosing a breaker rating based on its asymmetrical rms rupturing rating. The longer time delay required of the back-up breaker may require it being chosen on the basis of a one second rather than the instantaneous rating.

A MODERN STEEL MILL

The modern steel mill utilizes all of the forms of relaying that have been discussed in the foregoing. In Figure 10, P indicates the use of pilot wire relays, O denotes overcurrent time delay relays, and I, instantaneous overcurrent relays. In this particular mill, lines that formerly would have required power directional overcurrent relays are shown equipped with pilot wire relays.

Overcurrent time delay relays are used profusely especially on the low voltage circuits and emergency tie lines. In some cases these time delay overcurrent relays are equipped with instantaneous elements set for high values of fault current. This is usually done when a relay is located on the primary of a transformer bank. The relay is then able to distinguish between faults on the transformer primary and secondary by current discrimination.

Instantaneous overcurrent relays are shown on the feeders radiating from the 460 volt buses. In some cases

these are inherent trip coils built into the breaker but the final result is the same as though an instantaneous relay were used.

All major buses are equipped with bus differential relays. Where bus tie breakers are used, two sets of relays are installed, one for each bus section.

No attempt has been made to show apparatus protection such as would require transformer or generator differential relays, etc. since only relays for distribution lines were intended to be covered in this article.

For a period of forty years the relay art has advanced to meet the demands of industrial and central station engineers for adequate protection of apparatus and lines. The advent of the a-c network calculator made it possible to study intricate systems and to show the advantages of high speed relays in maintaining system stability.

The pilot wire relay and the bus differential relays, described in the foregoing are of the latest developments in the relay art. The induction time delay overcurrent relays are the results of the very early developments of thirty years ago.

The modern steel mill, as has been shown, requires and utilizes all of these relays from the oldest to the most modern.

DISCUSSION

PRESENTED BY

R. S. SMITHLEY, Duquesne Light Company, Pittsburgh, Pennsylvania

H. A. P. LANGSTAFF, Electrical Engineer, West Penn Power Company, Pittsburgh, Pennsylvania

F. MOHLER, Engineer, Steel Mill Section, Industrial Engineering Division, General Electric Company, Schenectady, New York

B. M. JONES, Duquesne Light Company, Pittsburgh, Pennsylvania

R. S. Smithley: I think Mr. Fountain has covered the protection of distribution systems for the steel mill supply very well, and I think you can see the complexity involved and realize how they tie in with and their similarity to the utility systems.

I would like to mention two points in particular. Mr. Fountain has brought out many protection schemes for distribution systems. Although he confined his remarks to the distribution systems, I would like to make one remark concerning equipment protection.

We know that for motor protection a great deal of under voltage protection is used. I would like to point out that very frequently for faults elsewhere on the system, the under voltage protection will cause the disconnection of motors which really do not need to be disconnected, because of the dips in voltage caused by the clearing of faults elsewhere on the system. We would like to advocate that this under voltage protection be made time delay, so that momentary dips in voltage would not take the machines off, and yet the protection would still be utilized whenever it was called upon because of the failure of voltage on the bus to which the machines were connected.

Mr. Fountain thoroughly covered pilot wire protection of lines, and I would like to say that, as far as our utility is concerned, we apply pilot wire to all our lines wherever it is economically possible. We have a great many installations of this particular type of pilot wire.

We have encountered some difficulty which I imagine might be encountered on the steel company systems. The pilot wires, of course, are exposed to some troubles and although there is supervision provided, we have found that it is advisable to interlock the pilot wire relays with over-current or under voltage relays. Hence, for external interference on the pilot wires or the introduction of foreign voltages, the pilot wire relay will not trip the breaker incorrectly. The breaker can only be tripped when the under voltage or over current relays indicate that it should be.

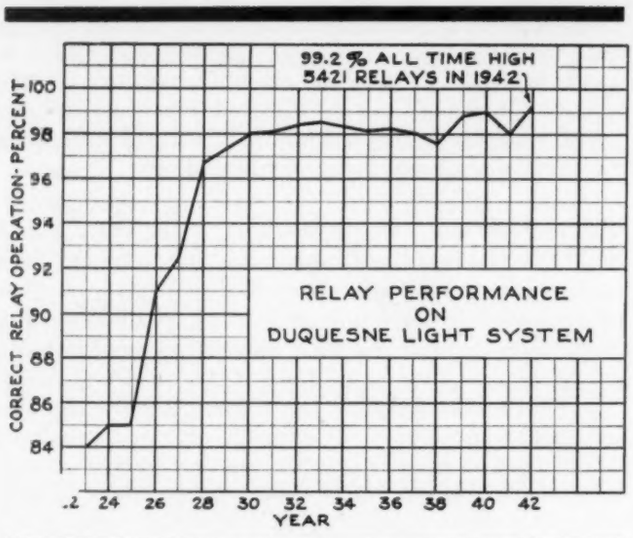
Mr. Fountain has brought out the problem of continuity of service, and I think that is one of our major interests as far as the utilities go. We pursue a very rigid program of maintenance and inspection of all protective equipment. Breakers are tripped manually from controllers at three-month intervals. They are tripped from relays at about one-year intervals. Every relay is calibrated or checked at two-year intervals, and the current transformers, potential transformers and control cables are checked and meggered at somewhat longer intervals.

We believe that this program has paid dividends. Some twenty years ago our protective relay performance had a figure of correctness in the neighborhood of fifty per cent. At the present time, when the availability of the equipment is most necessary, this figure has risen to slightly over 99 per cent.

H. A. P. Langstaff: I do not know that I can add anything to the papers that have been presented and comments that have already been made thereon. I would like to again stress this word "simplicity" which has always been our watchword in making applications in relaying and controls. I would continue to stress the importance of proper application of instantaneous voltage relays which have been discussed for a good many years. We should continue to guard against their wrong application. In all contracts and purchases, make certain that your relay applications are properly coordinated.

Along with modern relay applications where rapid clearing of faults and reduction in damage to equipment can be obtained more complicated circuits seem absolutely necessary and are well justified. All operating utilities have to contend with high tension lines serving numerous customers and high speed functioning of apparatus minimizes system disturbances.

F. Mohler: I have been particularly impressed by the many references today of your desire for simplicity in your electric equipment, especially in connection with the relaying of your systems. I too am very much interested in simplicity, but I am completely baffled as to how to relay your systems and obtain the degree of



protection and selection you desire without some complication.

Most of your systems have grown beyond all conceivable proportions when they were started. This growth has led to many complications and few systems have been gone over and revamped completely so that the system protection would be compatible with the extent of the distribution.

Personally, I know of no better way of obtaining the degree of protection which you desire and should have than by using overlapping differential relays.

Since there is such a desire for simplification, I think it would be highly desirable if some of the operating people be asked to present a paper on their ideas regarding this simplification.

B. M. Jones: One point not brought out at this meeting although it may be contained in the author's paper and written comments thereon, is the very important fact that the primary purpose of the relay protection, simple or complicated, is to isolate the fault so that the remainder of the electric system can carry its load and do its work. However, there is an additional point in the relay protection scheme which is very important, and that is to de-energize the faulted circuit or equipment in a very minimum of time so as to reduce the damage, and correspondingly the cost of repairs, but in the case of overhead conductors to reduce the damage to the point where the burning is very minute and service can be restored promptly without repairs. This latter is a most important point and is secondary only to the isolation of the faulted equipment or line from the rest of the system.

On the Duquesne Light Company system, this matter of clearing faults on overhead conductors rapidly receives considerable attention and has been paying dividends for years, for the percentage of lines restored to service promptly and remaining in service (which means that the burn was insufficient to burn down the conductor or reduce its carrying capacity materially) has steadily increased and is now of the order of 90 per cent of faulted lines.

I would like to add an echo to Mr. Smithley's point on testing, inspection and maintenance schedules for relays and associated protective equipment — not only the little relay costing $50 to $100, or $200 maybe, on the panel itself, but all associated wiring, contacts and auxiliary relays, current transformers, potential transformers, battery and terminals, circuit breaker mechanism and latch, etc. — all of the dozens of pieces of equipment that go to make up a complete protective equipment. The protective equipment is altogether different from a piece of working equipment, for the motor is working practically all the time it is in service and the operators can read the amperes and tell how it is operating or can tell from the heat of the bearing or the smoke coming out of the motor maybe, but for a protective system there are no indications of its ability to perform other than by an orderly testing schedule.

These devices should have a regular schedule of checking and testing to insure their being able to operate — for the relay protective system just sits idly by and does nothing until there is a fault and then it is supposed to do its stuff having had little practice or experience previously. To my mind, this makes it all the more imperative that the testing and inspection schedule be determined very carefully and carried out in a very thorough manner.

I was particularly interested in Mr. Fountain's description of bus differential protection (Figure 7), as this, to my mind, is very important. We have used this protection for some 20 years or so and rather extensively in the last 15 years, and now install it on all important buses.

In 1942, there were 5421 purely protective relays in service and many thousands of associated pieces of apparatus and equipment. The relay performance for 20 years, from 1923 through 1942, is shown in the accompanying graph, and it is interesting to report that during 1942 there were four months during which the relay performance was 100 per cent, again an all-time high. The average performance for the last 10 years was 98.32 per cent, with several 100 per cent months in many of those years. These records are based upon the performance of the entire protective unit up to and including the latch of the circuit breaker, and covers the protective relays, auxiliary relays, current transformers, potential transformers, control and switchboard wiring, test switches (jacks), tripping battery and its wiring, trip coils, tripping mechanisms, etc.

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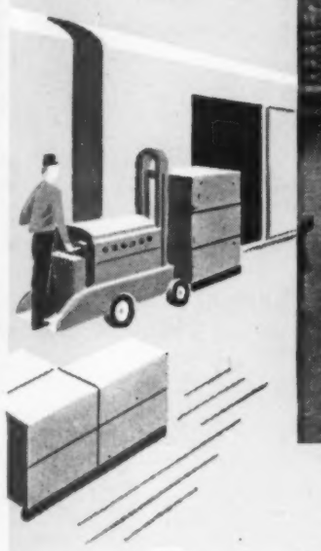
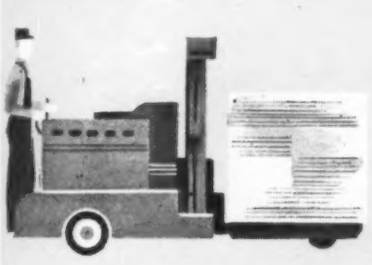
Designers and Builders
of
MELTING • HEATING AND
INDUSTRIAL FURNACES

Typical motorized hand lift truck





6 cells of Philco Battery Type 11 XL

GIVE YOUR
MOTORIZED HAND-LIFT TRUCKS THIS

10% EXTRA WORK CAPACITY

WITHOUT INCREASE IN BATTERY BOX DIMENSIONS

WHEN materials pile up, that's when the 10% extra capacity built into Philco XL Batteries can be a life-saver!

In this ultra-modern storage battery designed by Philco, you'll find the extra reserve of power you need to keep your trucks on the job longer hours—to deliver the extra wallop when needed—to haul more material each day.

Let us show you how Philco XL extra capacity Batteries today are solving the materials handling problems at crowded war plants, warehouses and ports of embarkation. Write for Industrial Truck Battery catalog. See directory for local Philco representative.

PHILCO CORPORATION
STORAGE BATTERY DIVISION, TRENTON 7, N. J.

Specify

PHILCO

INDUSTRIAL BATTERIES

"To Prevent Needless Welder Shutdowns at Globe Shipbuilding Company We Installed BUSS Fuses,"

Says CONTRACTOR, MR. FRANK MAHAN OF BENSON ELECTRIC COMPANY, SUPERIOR, WISCONSIN

"At the Benson Electric Company," adds Mr. Mahan, who is manager and chief electrical engineer, "we have standardized on BUSS Super-Lag fuses for the past 7½ years, using them exclusively on all wiring and motor installation jobs.

"We have found that BUSS Super-Lag links and the design of BUSS fuse cases can be depended upon to prevent needless shutdowns of heavy starting equipment such as welders and motors. It is doubly important in shipyards like the Globe Shipbuilding Company, that are rushing material for war, that outages be held to an absolute minimum.

"This installation includes 10—400 ampere feeder circuit switches. Off each is run 24—60 ampere circuit switches serving electric welders.

"From our past experience we are sure that the installing of BUSS Super-Lag fuses at Globe Shipbuilding Company will eliminate many needless production losses."

Why BUSS Fuses Don't Blow Needlessly

10 FEATURES in the design of the FUSE-CASE help make it possible...

plus

The SUPER-LAG development in the FUSE-LINK completes the job.

BUSS Super-Lag

You, too, can profit by standardizing on BUSS fuses

Mr. Mahan's experience that led him to specify BUSS fuses at Globe Shipbuilding Company is a typical reaction of men who have tried these fuses. It is proof that shutdowns caused by needless blows can be prevented—and adequate protection can be provided in the same protective device.

As for BUSS Super-Lag fuses—the experience of thousands of plants throughout all industry has proven time and again that by using them you can obtain trouble-free protection at a lower overall cost than with any other renewable fuse.

They require no maintenance or periodic inspection. They don't open needlessly. If one opens, you know there is some fault that needs correction.

Here is Why BUSS Super-Lag Fuses Greatly Reduce or Entirely Prevent Needless Blows

The fuse case is designed to insure good contact on the link, even when the fuse is renewed by an inexperienced person—and it is so designed that vibration or heavy overloads or the constant heating and cooling of the fuse will not permit poor contact to develop. Thus, excessive heat which causes fuses to blow when they should not is prevented.

The fuse link used is the famous "BUSS SUPER-LAG." It has lag-plates attached which give it a long time-lag so that unusually heavy starting currents or other harmless overloads will not cause the fuse to blow.

And Here is How to Solve the "Shutdown Problem" in Your Own Plant

Pass the word along that all purchase records dealing with circuit protective devices should be immediately changed to call for BUSS Super-Lag Renewable fuses. Then, as fuses are replaced or new installations made, your plant will automatically get the benefit of the carefree, trouble-proof protection that BUSS Super-Lag fuses give.

BUSSMANN MFG. CO., University at Jefferson, St. Louis, Missouri, *Division McGraw Electric Company.*

FUSES Sold Through Wholesalers

"Now, I don't mean purchase price...LUBRIPLATE probably costs a lot more per pound than the grease you are now using... what I'm getting at is the over all costs.

"LUBRIPLATE lasts longer...yes, it does. You see the film is tougher...it stands up longer. A lot of fellows who use LUBRIPLATE tell me they have been able to stretch their lubrication schedules. This in itself is a saving.

"But the big thing is LUBRIPLATE arrests progressive wear and prevents rust and corrosion. Sure you save on parts replacement and machine shutdown...and as to lubrication...LUBRIPLATE is the slipperiest stuff you can put on a bearing. Of course it saves on power. All and all LUBRIPLATE is the most economical lubricant you can use."

• • •

Don't take our salesman's word for the economy and efficiency of LUBRIPLATE. Let us send the "LUBRIPLATE FILM" written especially for your industry. Read the case histories and unsolicited testimonials of other users. Write for a copy today.

℞ FOR YOUR MACHINERY

No. 3—Ideal for general oil type lubrication. Ring oiled bearings, wick feeds, sight feeds and bottle oilers.

No. 8—Because of its high film strength and long life reflects outstanding performance in most types of enclosed gears (speed reducers).

No. 187—One of the most popular grease type products for general application by pressure gun or cups.

No. 70—For a wide range of grease applications, especially at temperatures above 200 degrees F.

No. 130-AA—Known nationwide as the superior lubricant for open gears, heavy duty bearings, wire rope, etc.

BALL BEARING—This is the LUBRIPLATE lubricant that has achieved wide acclaim for use in the general run of ball and roller bearings operating at speeds to 5000 RPM and temperatures up to 300 degrees F.

LUBRIPLATE DIVISION
FISKE BROTHERS REFINING COMPANY
NEWARK, N. J. **SINCE 1870** TOLEDO, O.
WRITE FOR THE NAME OF THE DEALER NEAR YOU

Is Your Problem one of Stacking to conserve Floor Space?

Hundreds of plants and warehouses have solved this and other material handling problems with Baker Trucks. So that you may profit from their experiences, a large part of our new catalog has been given over to actual installation stories. A few cases in point are listed below:

★ ★ ★

A leading industrial engineer was given the job of designing a large model warehouse for the world's largest paint manufacturer. Baker Trucks and Tractors were specified to bring about top efficiency in the sorting, storing and shipping of the more than 10,000 items handled in this warehouse. Illustration shows one of their fork trucks stacking pallet loads of drums three-high.

One of the problems confronting the planners of this warehouse was to find a way of getting at "buried" loads with a minimum of time and effort. This was solved by steel racks—permitting the fork truck to remove the lower pallet without disturbing cartons above.

A large west-coast processing plant saves thousands of dollars annually through the use of telescoping lift trucks. The Baker Fork Truck illustrated is tiering heavy pallet loads three- and four-high to conserve warehouse space.

In paper mills, print and publishing shops, Baker Trucks have more than doubled the value of warehouse space by permitting stacking to the ceiling. Reductions up to 80% in handling costs are reported. One publisher paid for his truck in 18 months' rental savings alone.

A Baker Material Handling Engineer was called in to make a survey of a large food warehouse. Upon his recommendations, a fork truck plus a conveyor system was installed. Operating costs were reduced from 6.68c to 4.98c per ton, a saving of 25.4%. Gross savings amounted to $153 per week or $7956 per year.

The problem of stacking steel sheets has been successfully met in steel mills and metal working plants through the use of heavy duty fork trucks, handling sheets on pallets—or equipped with rams for handling heavy rolls. A special roll-over attachment tiers rolls either vertically or horizontally.

If you have a material handling problem and are looking for the best answer, your nearest Baker Material Handling Engineer will gladly help you.

BAKER INDUSTRIAL TRUCK DIVISION *of The Baker-Raulang Company*

2166 West 25th Street • Cleveland, Ohio

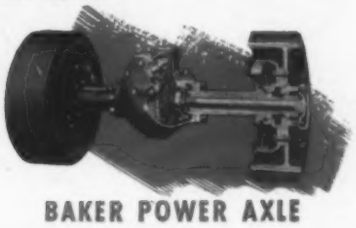
In Canada: Railway and Power Engineering Corporation, Ltd.

LOOK AT THESE BAKER CONSTRUCTION FEATURES BEFORE YOU BUY AN INDUSTRIAL TRUCK

Every part of every Baker Truck has been especially designed and developed for its specific function. Many Baker features are exclusive, others, pioneered by Baker are now standard in the industry.

BAKER NO-PLUG CONTROLLER

Promotes easy and safe operation, and protects truck life by compelling drivers to use acceleration steps. Accidental plugging from forward to reverse is prevented. Complete control is by one handle.



BAKER POWER AXLE

Exclusive Baker design—construction and materials designed for most efficient operation, low maintenance and long life. Hardened alloy steels are used in all vital parts. All bearings, axle shafts and universal joints are dust-protected.

BAKER-BUILT MOTORS

All motors are designed and built by Baker to give greatest efficiency for their specific function. Truck motors develop highest H. P. and contain more copper and iron than any others of the same size. Top efficiency is assured by ground fit between field ring and poles, heavy forged commutator bars and large brush surface. Brushes and armature shafts are easily accessible for adjustment or replacement.

WRITE FOR YOUR COPY

Plant and production managers, traffic managers, superintendents, purchasing agents and any others concerned with material handling will find the new Baker Catalog No. 52 a valuable reference.

CHATTERING BRUSHES?

Check
for these causes:

1. **Rough commutator or slip rings**
2. **High mica**
3. **High bars**
4. **Flat spots**
5. **Worn holders**
6. **Incorrect spring tension**
7. **Too high friction brushes**
8. **Wrong holder adjustment**

Beware of noisy brushes on motors and generators! Their tell-tale chatter is fair warning that something is wrong with the commutators, brushes or holders — that machine performance is not up to par. It is your cue to check for the causes and remedy them as soon as possible.

On this or any other commutation problem, SPEER can help you speed your trouble-shooting — is ready to give you the benefit of its 45 years in finding the right solution for them. Why not take advantage of this service? Just write on your business letterhead for SPEER Brush Data Forms — one for each machine on which you have a commutation problem or whose performance you think should be better. As soon as you return the form to us, filled in, our recommendations will be sent back to you promptly. That's all there is to it.

It's up to you whether or not you follow our suggestions. In any case, there is no obligation. This is a wartime service SPEER is glad to perform — without charge — to help brush users to save time, expense and power through better commutation. It is yours for the asking — anytime.

SPEER
CARBON COMPANY
SCC
ST. MARYS, PA.
CHICAGO · CLEVELAND · DETROIT
MILWAUKEE · NEW YORK · PITTSBURGH

5526

LAY THAT "BELT" DOWN ON

LINK-BELT

ANTI-FRICTION

BELT CONVEYOR IDLERS

. . . and be assured of maximum belt life, minimum power and maintenance cost, and dependable trouble-free conveyor service. Link-Belt engineers pioneered in the development of anti-friction belt conveyor idlers and have consistently improved the original, fundamental design—the grease seal, bearing adjustment, shaft mounting and the supporting stands and brackets. All with the result that today's Link-Belt designs offer the very best in belt conveyor equipment. 9451-A

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Pittsburgh19, Atlanta, Dallas 1, Cleveland 13, Detroit 4
Minneapolis 5, San Francisco 24 Toronto 8 Offices, factory branch stores and distributors in principal cities.

LINK-BELT

BELT CONVEYOR EQUIPMENT

IDLERS • TRIPPERS • BELTS • PULLEYS • BEARINGS • DRIVES

NEWS SUPPLEMENT *April 1944*

Equipment
Personnel
Literature

Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

U. S. STEEL OPENS TUBULAR ALLOY PLANT AT GARY

▲ United States Steel's newest addition to the war effort in its Chicago district operations — the Gary plant of the Tubular Alloy Steel Corporation — was formally opened April 5th. The plant is making a vital contribution to the war, and it is one of the largest plants in the nation devoted exclusively to the manufacture of alloy seamless and stainless steel tubing of all types.

Leaders from the armed services, government and business, as well as industrial labor and management, assembled in Gary for the opening event, which included an inspection trip in the morning followed by luncheon. Charles R. Cox, president of Tubular Alloy and of National Tube Company, also a United States Steel subsidiary, and E. N. Sanders, vice-president in charge of the Gary plant, were hosts for the opening.

Tubular Alloy occupies 37 acres of industrial buildings in Gary, originally constructed for the National Tube Company and recently converted to meet present needs. It employs nearly 3700 men and women. Much of the plant's production is for aeronautical purposes, while the remainder is for Army and Navy ordnance. The war products include tubing for component parts for Army and Navy aircraft, for tank pins, tank pin bushings and other military tank parts, and for other military heavy-duty motor requirements, such as airplane, truck and tank engine bearings.

Other products include super-heater and condenser tubing for Navy and maritime use in steam and diesel-driven vessels and for the oil refining and rubber industries.

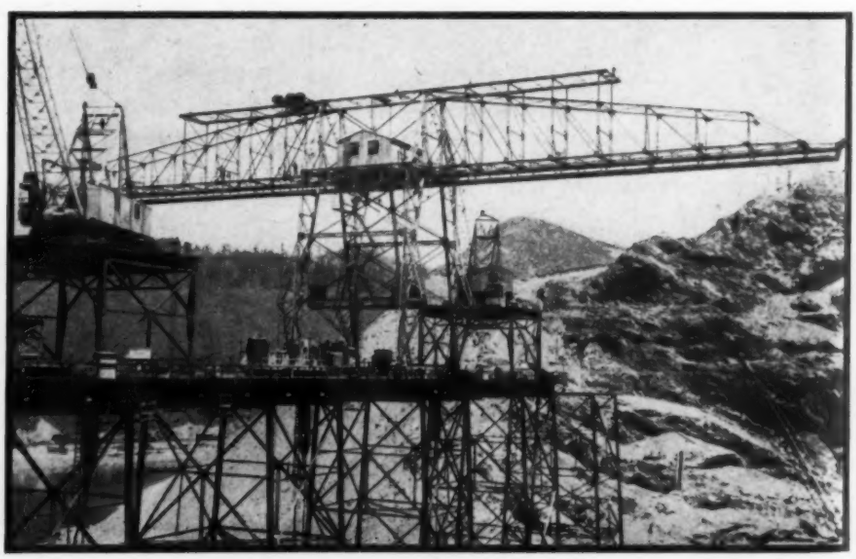
The plant was developed at the suggestion of the Office of Production Management. Tubular Alloy owns the tract, plant buildings and service facilities, but leases all equipment — machine tools, motors and production machinery — from the Federal government through the Defense Plant Corporation. The actual conversion of the existing facilities, as well as the addition of new equipment, was carried through by the personnel of the Tubular Alloy Steel Corporation, acting as agents for Defense Plant Corporation.

NEW ELECTRIC HOIST DRIVE FOR CRANES

▲ A new electric hoist drive for cranes, the important feature of which is an exciter embodying a cross-flux principle, was described recently by M. A. Whiting, of the Industrial Engineering Division of the General Electric Company. The new drive system not only automatically "weighs" the load so that it is hoisted and lowered at the maximum safe speed, but also prevents the handling of dangerous overloads. Safety features inherent in the fields and circuits of the system enable it to provide this degree of control without the use of mechanical relays or similar devices.

Although the new system is not designed for use in all types of hoists, it has already been successfully applied to two high-speed, high-lift cranes at the TVA Fontana Dam, near Fontana, North Carolina, which place concrete at the rate of almost eight tons a minute. Also, among the several applications for which the drive is believed to be equally suitable, the high-grade, heavy-duty indoor cranes in steel mills and heavy machine shops may be considered typical.

One of two cantilever cranes in use at the TVA dam near Fontana, North Carolina.



DE LAVAL WORM GEARS for Slow Motion!

Double-reduction worm gear for vertical drive; the driven shaft may extend up or down.

Double-reduction worm gear for horizontal drive

De Laval double-reduction worm gears are made in ratios from 50 to 1 up to 8000 to 1.

A rigid cast iron housing maintains the worms and worm gear in perfect alignment, serves as an oil well, protects the working members from dirt and moisture, and eliminates danger to operatives.

There are only three working members, namely, the high-speed worm, the gear with which it engages and which is mounted upon the slow-speed worm, and the slow-speed gear and shaft.

The high-speed gear and the slow-speed worm dip in a reservoir of oil, lubricating all tooth and thread contact surfaces, while the ball bearings supporting both the high-speed and the slow-speed worms are immersed in oil. The slow-speed gear bearings are amply proportioned and effectively lubricated to withstand the considerable forces involved in a high-ratio reduction.

De Laval single-reduction worm gears are built for ratios from 4 to 1 up to 100 to 1 and for either horizontal or vertical drives.

1140

De Laval Worm Gear Division
of the
De Laval Steam Turbine Co., Trenton 2, N. J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC. PUMPS . . . CENTRIFUGAL, CLOGLESS, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, PROPELLER; PRIMING SYSTEMS; CENTRIFUGAL BLOWERS and COMPRESSORS. GEARS . . . WORM, HELICAL and FLEXIBLE COUPLINGS

The equipment consists of a generator, a cross-flux exciter, and an ordinary constant-voltage exciter driven by an induction motor, or if preferred, by a synchronous or a d-c motor. The hoist motor is of the type which is standard for high-speed crane-hoist installations, except that it has a non-standard main field for a variable separate excitation.

The cross-flux exciter is really the brain of the drive system. This exciter is designed and connected to the system so that an increase in load on the hoist, either motoring as in hoisting, or regenerative as in lowering, reacts on the field of the exciter, causing it to strengthen the hoist motor field and simultaneously weaken the generator field, the degree depending on the magnitude of the load.

Since the generator supplies the power to the hoist motor armature, weakening the generator field reduces the voltage impressed on the hoist motor armature and reduces its speed. Also, strengthening the hoist motor field further reduces the motor speed. In addition, strengthening the motor field corrects the ill effect of armature reaction and prevents any trend toward instability. A decrease in hoist motor load, either hoisting or lowering, has the opposite effect, thereby increasing the speed of the hoist motor. In this case, however, there is no necessity for armature reaction correction since the decreasing load automatically reduces its effect.

This effect from the cross-flux exciter is partly brought about by energizing one of its fields by series turns through which the current in the hoist motor armature flows. Since this current flows in the same direction whether motoring or regenerating, remembering that rotation reverses, the effect on the hoist motor field and the generator field is the same in both cases, as it should be. The method of interconnecting the motor field, the generator, and the cross-flux exciter armature is also important in producing these effects.

This drive system is not to be considered as preferable or even applicable for all types of hoists, but is intended for use in those types in which, although substantially different as to design and use, the various combinations of speeds and loads are similar.

Are you interested in Saving

MAN-POWER
FUEL
MATERIAL
This Gage will do it!

HAYS VISIO-RATIO GAGE

IT SAVES IN MAN POWER because it eliminates the necessity of making calculations to determine air excess or deficiency—does away with lost time in making experimental adjustments.

It saves in fuel because it indicates instantly when there is an incorrect proportioning of air and fuel. It is an infallible guide to highest possible combustion efficiency.

It saves in material through producing greater uniformity in production methods, in minimizing spoilage, etc. It may be used for indicating not only the ratio of air flow to fuel flow—but the ratio between other functions such as pressure, draft, suction, temperature (up to 1000° F) speed in R.P.M. or inches per minute, position, level and others.

The cross-pointer feature is exclusive with the Hays Visio-Ratio Gage. It shows at a glance not only the amount of the two flows but the percentage of excess or deficiency existing between them.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROLS
MICHIGAN CITY, INDIANA, U.S.A.

Send for
PUBLICATION 41-478
ON CENTRALIZED
CONTROL OF OPEN
HEARTH FURNACES

MANUFACTURER CHANGES CORPORATE NAME

▲ Continental Roll and Steel Foundry Company announces that its corporate name has been changed to Continental Foundry and Machine Company. The change in name was adopted for the purpose of describing more clearly the company's productive facilities. It in no way affects the corporate structure, management, personnel, policies or products of the company.

Continental has four plants located at Coraopolis, Pennsylvania, East Chicago, Indiana and Wheeling, West Virginia. These plants produce cast armor, carbon and alloy steel castings ranging from 100 pounds to 260,000 pounds.

Continental also designs and builds blooming, merchant, structural and tube mills, roll lathes and other heavy machinery for the steel industries. In addition, Continental is one of the largest producers of carbon, alloy steel, plain iron and iron alloy rolls.

HAVAS, PRICE, TELL OF KAISER STEEL PLANT CONSTRUCTION, OPERATION

PURDY PIX

George Havas, chief engineer, and T. M. Price, works manager, Kaiser Company, Inc., discussed the construction and operation of the Kaiser steel plant at Fontana, California, at the March 28th meeting of the Engineers' Society of Western Pennsylvania in Pittsburgh. Shown above are Mr. Havas, W. P. Witherow, president of Blaw-Knox Company, W. C. Snyder, Jr., president of Lewis Foundry and Machine, and Mr. Price. Among the 200 attending the meeting were J. J. Huether and L. F. Worden (right) of General Electric Company. Below, T. C. Campbell, of Iron Age, interviews S. S. Marshall, Jr., vice president of Jones and Laughlin Steel Corporation, during a dinner which preceded the meeting.

MORE RECORDS FOR WEIRTON STEEL

▲ Eleven new major departmental records were set during the month of March in plants of the Weirton Steel Company.

The records set new highs for net tonnage produced in the blooming mill, galvanizing department, 48-inch hot mill, 48-inch mill No. 3 continuous pickler, 48-inch mill No. 5 tandem mill, 48-inch mill, total 4-high cold rolling, total production of the 10-inch, 16-inch and 48-inch hot mills, total shipments of the 10-inch, 16-inch and 48-inch mills, Weirton tin mill skin rolling, electrolytic tin plate production, and lacquer plate production.

A. I. S. E. BIRMINGHAM DISTRICT SESSION CLEEBRATES SILVER ANNIVERSARY

The A. I. S. E. Birmingham District Section, on March 27th, celebrated the 25th anniversary of its founding with a dinner and meeting. Seventeen past chairmen were in attendance, as well as many prominent industrialists from the Birmingham area. Shown here are J. S. Lother, vice-chairman of the Birmingham Section; Brent Wiley, managing director; John Dugan and George Griffiths, both of Ohio Steel Foundry, authors of a technical paper presented at the meeting; C. L. McGranahan, A. I. S. E. president; and A. L. Lemon, secretary of the Birmingham Section.

WEIRTON TO MAKE EXPLOSIVE SHELLS

▲ To fill an urgent war department contract, the Weirton Steel Company will enter the direct production of war munitions for the first time in its history, when it begins the manufacture, in the near future, of large caliber explosive shells, it is announced by Thomas E. Millsop, president, whose company has been devoted almost exclusively to the production of war material since Pearl Harbor.

Production of shells will start as soon as the necessary equipment and facilities can be installed and placed in operation, Mr. Millsop said. Approximately 1500 additional employees will be required for the new operations.

The Weirton Steel Company will conduct all manufacturing operations, beginning with the production of forging steel shell billets, and will ship finished shells to United States Army arsenals for loading.

The Weirton Steel Company was selected to enter this new field of production, according to Mr. Millsop, because of a situation that has developed in the supply of certain types of munitions and because of the company's previous success in solving production problems that confronted the United States Army Ordnance Department.

"We regard this order as a tribute to the record that has been made by the 12,000 men and women of the Weirton Steel Company not only for doing things but also for doing things quickly and well," Mr. Millsop said.

Lt. Col. Robert L. Downie, chief of the Pittsburgh Ordnance District, also commented on the placement of this large order for shells with the Weirton Steel Company. "Our men and women on the fighting fronts must be supplied with ammunition," he said. "This important job that we have placed with the Weirton Steel Company must be done and done quickly. We are confident that it will be done."

Work will start immediately on alterations to plants and installation of new equipment necessary to the manufacture of the shells. It is estimated that this program will cost from four to five million dollars. The new facilities required will include forging presses, complete heat-treating installations, and machining equipment.

Manufacture of the shells will start with the production of forging steel in the open hearth department. This special steel will then be rolled in the blooming mill and structural mill into shell billets.

The process of shaping the billets into finished shells will begin with forging and heat treating operations which will be conducted on new equipment that will be installed in the 28-inch mill warehouse building in Main Street, Weirton. Following these operations, the shells will be taken to the Steubenville plant of the Weirton Steel Company for machining, finishing and shipment to arsenals.

Approximately 12,000 tons of ingot steel per month will be required to maintain the full schedule of shell production.

OKOLITE-OKOPRENE CABLES

HAVE HIGH RESISTANCE TO OIL, ACIDS AND CORROSIVES

TEST 1
After 7 days immersion in benzine, the insulation on braided cable was destroyed (left), rubber sheaths became soft, increased 51.7% in diameter (center), while Okoprene stayed in excellent condition and increased only 22.1% in diameter.
TEST 2
H₂SO₄
In sulphuric acid battery electrolyte of specific gravity 1.300 at a temperature of 160 deg. F., the Okoprene sheath was in good condition after 21 months immersion.

Okolite-Okoprene cables are designed to resist oil, acids and other corrosive chemicals. The Okoprene sheath also provides added electrical protection.

Moisture-resistant, tough and long-lived, Okolite-Okoprene cables require no additional covering. They are self-contained. Yet with all their advantages they cost no more than high grade braided cables. Millions of feet are giving highly satisfactory service in refineries, chemical plants, mines, railroads and other electrical applications where other cables do not last.

GREATER RESISTANCE TO OIL — When exposed to the solvent action of commonly prevalent petroleum products, Okoprene sheaths protect the wire insulation from swelling and softening. Unlike rubber, Okoprene sheaths retain their full mechanical strength after such exposure.

NOT ATTACKED BY CORROSIVE CHEMICALS — The Okoprene covering has excellent resistance to most acids, alkalies and other corrosive chemicals.

Insulated with Okolite oil-base insulation and protected by a sheath of Okoprene, moisture-resisting Okolite-Okoprene cables (U. S. Patent 2,312,058) may be installed in ducts, buried directly in the earth or exposed to the elements without additional protection. *Simple to handle, splice and terminate, they are available in all standard sizes and many colors for service up to 5000 volts. For further details, send for Bulletin OK-2009C.* The Okonite Company, Passaic, New Jersey.

LOOK FOR THE SINGLE RIDGE ON OKOLITE-OKOPRENE

OKONITE INSULATED WIRES & CABLES

3592

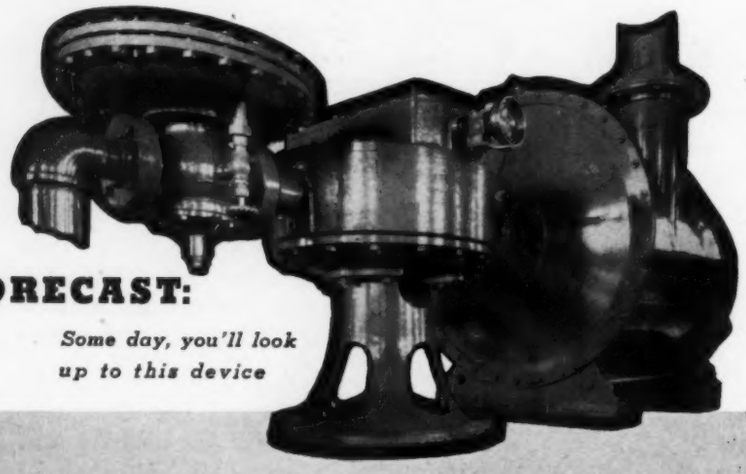
PITTSBURGH STEEL SHOWS REDUCED PROFIT

▲ Annual report of the Pittsburgh Steel Company shows a net profit for 1943 of $1,734,222 after all charges as compared with $2,488,074 in 1942. Net profit for 1943 was equivalent to $1.71 a share on 508,917 shares of common stock after deduction of preferred dividends accrued for the period. This compares with $3.19 on the common stock in 1942.

Renegotiation under the War Profits Control Act resulted in a refund of $515,000 from earnings of 1942, subject to approval by the Secretary of War. After taking into consideration the resulting reduction in federal excess profits taxes and credit for debt retirement, the refund will reduce the net profit previously reported for 1942 by $97,850. A part of the company's sales for 1943 is subject to renegotiation but it is believed that no provision will be necessary for such a refund.

In a report to the stockholders of Pittsburgh Steel Company, Joseph H. Carter, president, said that during the year 1943, $2,505,155 was spent on plant improvements and betterments as compared with $5,457,009 spent for the same purpose in the previous year. The installation of additional cold drawing facilities for the manufacture of certain types of seamless tubes at the Allenport plant by the company, as agent for Defense Plant Corporation, was completed in the spring of 1943 and that project is now being actively used by the company on a rental basis for the production of tubes needed in the war effort.

In November, 1943, the directors authorized the appropriation of $1,700,000 for the building of a new automatic tube mill at the Allenport plant to replace the present No. 3 mill. The new mill will have a range of sizes and an efficiency of operation that should result in a substantial improvement in the company's ability to serve the post-war demand for oil country pipe.



FORECAST:

Some day, you'll look up to this device

BASIC

in modern mill practice

This is the patented, exclusive Kemp Industrial Carburetor, the machine that provides complete premixing of gas and air to provide new savings, new heat liberation, new flexibility and new control in almost every type of ferrous and non ferrous heat processing.

As the basic unit in Kemp heat treating the Industrial Carburetor supports gas immersion melting in modern tin stacks, provides fuel for inert gas and for recirculating radiators in annealing covers, for Kemp Radiatube Roll Heaters, may be set for exactly the desired flame characteristics whether reducing, oxidizing or for complete combustion . . . and save 15 to 40 percent in fuel.

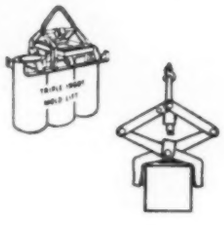
For engineering details and assistance, address **The C. M. Kemp Manufacturing Company, 405 East Oliver Street, Baltimore, Maryland**

The Army-Navy "E" Flag, awarded "for high achievement in the production of materials of war."

KEMP of BALTIMORE

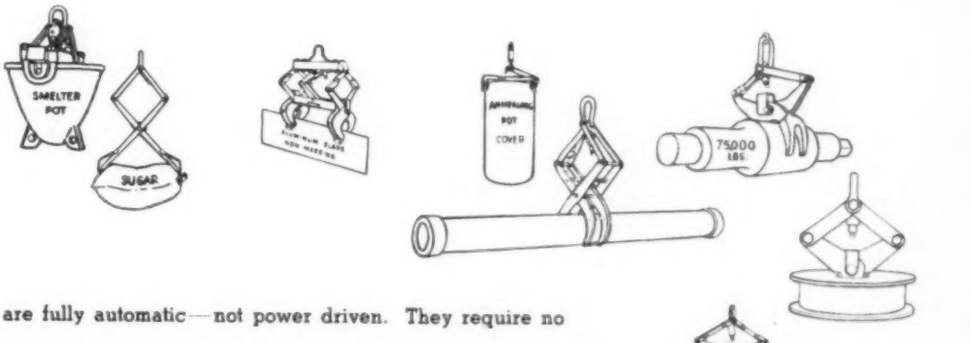
NEW BOILER RATIO METER ANNOUNCED

▲ Cochrane Corporation of Philadelphia, manufacturers of flow measuring instruments, steam power plant equipment and specialties, announces a new boiler meter of the steam-flow, air-flow type, known as the Cochrane boiler ratio meter. Several important advantages are claimed over other constructions on the market. The operator can establish the relation of air supply to fuel supply (measured by steam generated) most favorable to his particular operation by means of an easily adjustable cam in the air flow mechanism. Quick and easy reading is provided by a red indicating pointer operating across a white 10-inch scale, making it unnecessary to examine closely the position of the pens to determine whether the air is excessive or insufficient, as the movement of the pointer is 3 times as great as the differences between the pens. The steam flow mechanism is that of the standard Cochrane friction-free electric flow meter, operating on the null balance principle, assuring highest accuracy. The air flow mechanism is based on the highly responsive Hays slack diaphragm, equipped with an electric motor follow-up for ample power.



Handle your materials the modern way—
the faster, safer, more economical way.

Use Heppenstall Safe-T-Tongs



Heppenstall Tongs are fully automatic—not power driven. They require no ground crew. They pick-up, land and release a load by simply raising and lowering the crane. Their action is positive and completely efficient. They can be designed to handle any weight, shape or type of material. If you have any repetitive handling job in your plant, write for our Safe-T-Tong book. It may stimulate a profitable line of thought . . . Heppenstall Company, Department TP-1, Pittsburgh, Pa.

Forging Fine Steels for Over 50 Years

Heppenstall Automatic Safe-T-Tongs

NEW ROLLWAY BEARINGS

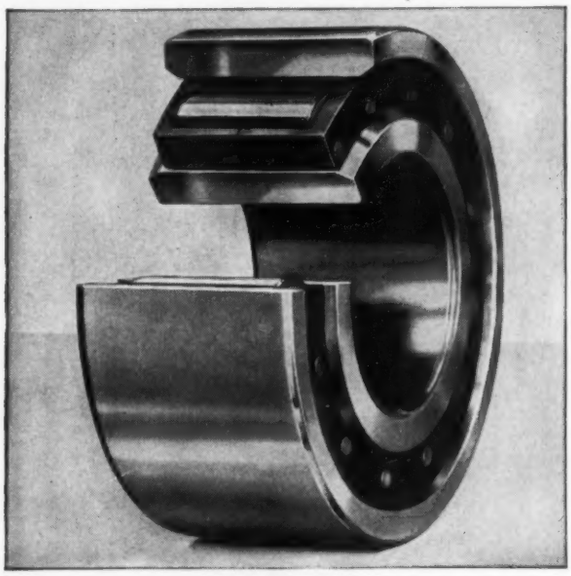
Earn 20 Times Their Investment Cost Annually

Let Us Analyze the Possibilities of Rollway Bearing Equipment in YOUR Plant

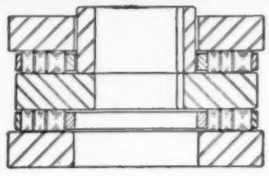
Think of it—just four Rollway bearings (two Couch Roll bearings and two Pressure Roll bearings) actually earned $250.00 per day or $75,000.00 per year for one plant. And when we say earned, we mean increased production that yielded a $75,000.00 gain in annual profit. *More than 20 times the cost of the bearings,* to say nothing of an average saving of 31 horsepower.

We don't say that every plant can show comparable gains simply by installing Rollway bearings, but we do believe that Rollway's right-angle loading of bearings will give the average plant:

1. **Marked increase in bearing life.**
2. **Marked improvement in the speed-load-life ratio of bearings.**
3. **Marked decrease in bearing replacements, shaft wear and maintenance time.**



Type CS Double Width Radial



Type DT Double Acting Thrust

For compound loads, diagram shows how SEPARATE radial and thrust bearings are used in combination:

- All radial loads carried at right angles to the roller axis.
- All thrust loads carried at right angles to the roller axis.

Simplifies the Load...

Rollway's right-angle loading splits the load into its two simple components of pure radial and pure thrust—each carried by a separate roller assembly. It eliminates all compound loads, all oblique loads and resultants, insuring greater load capacity in any given dimensional limit. There's no pinching effect to force rollers out from between the races, hence less roller-end wear-back and less rubbing or sliding friction. Starting and running torques are both lower; power consumption goes down.

Write today; let a Rollway engineer make a free bearing analysis of your plant; let us estimate the savings or earnings you might reasonably expect from Rollway's Right-Angle Loading.

ROLLWAY BEARING COMPANY, INC., SYRACUSE, NEW YORK

BUILDING HEAVY-DUTY BEARINGS SINCE 1908 **BEARINGS**

AMERICAN STEEL AND WIRE MILL PRODUCES VARIETY OF VITAL ITEMS

▲ In the background of the intricate pattern of the invasion of a continent is the detailed planning for a dependable and accurately timed supply of vital materials. Meeting this problem with increased wartime efficiency, the wire mill of the American Steel and Wire Company, U. S. Steel subsidiary at Worcester, Massachusetts, is turning out hundreds of tons weekly of round and shaped steel wire and strip products with production facilities and equipment of the most modern design.

This recently completed mill, part of an elaborate rehabilitation and improvement program undertaken by the wire company in Worcester, is not only the finest wire mill in New England but ranks as the largest of its type in the East. In the wire mill building, which extends over an area approximately 1/5 of a mile in length and 500 feet in width is housed all the necessary equipment to manufacture all grades and classifications of low carbon, high carbon and alloy steel wire and strip.

The number of uses to which wire and wire products are put in instruments of war is practically limitless. Literally countless thousands of individual items — some of them relatively small in size — total up to a tremendous tonnage, making a vital contribution to the construction of war machines for the Allied Nations.

From the wire drawing rooms, the cold roll department and the various other units under this one roof, pour forth the strategic materials needed for the activities of the armed forces. In one section of the new mill great quantities of stapling wire, aircraft stitching wire and stitching wire for G.I. shoes are drawn and processed. Also produced are the bundling and packaging wires which secure the crates and boxes containing the vital foodstuffs and hospital supplies for our fighting men. Here is drawn the wire for the springs in the intricate mechanisms of anti-aircraft, anti-tank and machine guns, ammunition and other precision instruments of modern warfare. Fragmentation bomb wire for bomb casings is an important part of daily production. A large percentage of the wire produced is employed in the formation of protective sheathing for shipboard and submarine cables. Workers in other departments draw wire for especially designed wire rope used in the anchor lines of barrage balloons, field strand and rope for the Army or for use in the control cables in Navy aircraft.

Much of the mill output goes to manufacturers to be fabricated into screws and bolts for use in the assembling of airplanes, tanks and guns as well as in the construction and repair of ships and landing barges. Many of the products of the nail mill facilitate the construction work of Army engineers which must be accomplished at a rapid-fire pace. These products also find their way into sturdy wooden vessels and barges.

From the output of strip steel which issues from the cold roll department of the wire mill are manufactured knives, feeler gauges, razor blades, saw blades and many other of the countless items used in modern warfare and production.

Throughout the mill these varied

Type GRF
CONDULETS

(CONDULETS are manufactured only by CROUSE-HINDS)

Type GRF Condulet for Surface Mounting. With Mounting Feet.

Type GRF Condulet for Flush Mounting. With Slotted Holes for Nailing to Concrete Forms.

Adaptable — many uses. Takes blank or hub covers; terminal blocks; many Condulet accessories; standard 4" outlet box covers and wiring devices. Can be used as a
Junction box Condulet
Plug receptacle Condulet
Lighting fixture Condulet
Fixture hanger Condulet

Convertible. At any time after installation Type GRF Condulets can be quickly converted to other uses, as all equipment is interchangeable.

Cast Feraloy (semi-steel). Strong and rigid. Wide gasket surface for tight and weatherproof assemblies.

Bosses for drilling and tapping on sides and back. Will be furnished blank or factory tapped with tapered threads in any arrangement for ½, ¾, or 1-inch conduit.

2 Styles. For flush or surface mounting.

3 Sizes. Inside depth, 1½, 2¼, or 3 inches.

Listed in Condulet Catalog No. 2500, Section 15, Page 31.

Flexible Cushion Fixture Hanger

Plug Receptacle

A Nationwide Distribution Through Electrical Wholesalers

Ceiling Type Vaportight Lighting Fixture

CROUSE-HINDS COMPANY
SYRACUSE 1, N. Y., U.S.A.

Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington
Resident Product Engineers: Albany — Atlanta — Charlotte — New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD., Main Office and Plant: TORONTO, ONT.

CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS

wartime products are kept constantly moving from the production and processing operations to the shipping platforms. A special truck materials-handling system hastens the progress of the invasion supplies on their way with comparative ease and rapidity.

Typical of the vital importance of the new mill are some of the annual capacity figures, which include 125,000 tons of steel wire, 13,250 tons of cold roll strip steel, 15,000 tons of nails and 35,000 tons of galvanized products.

GENEVA PLATE MILL STARTS OPERATIONS

▲ Less than two years after ground was broken on 1600 acres of farmland the plate mill of the Government's new $180,000,000 Geneva Steel plant near Provo, Utah, went into operation March 23 when the first trial rolling of plates was made. Geneva Works, largest integrated steel plant west of the Mississippi River, is being operated by Geneva Steel Company, U. S. Steel Corporation subsidiary, under contract with the Defense Plant Corporation for the war period.

First rolling of plates for the Pacific coast shipbuilding industry culminates a series of operating steps over the past few months which began with the charging of the first battery of coke ovens on December 13, 1943.

CARNEGIE-ILLINOIS SETS 23 RECORDS

▲ Carnegie-Illinois Steel Corporation announced that the company's steel workers in March established 23 new monthly unit production records including one of over twenty-seven years' standing.

The monthly blast furnace record at Edgar Thomson Works which has been on the books since October, 1916, was beaten when more than 215,000 tons of iron were produced by this department in March. Clairton Works also smashed an all-time blast furnace mark made in October of last year.

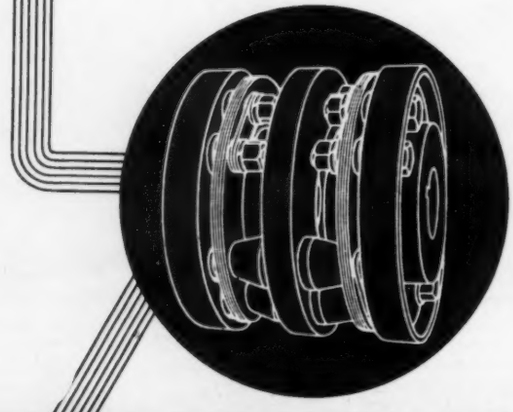
In production of open hearth steel, Homestead Works, with a total of more than 348,000 tons, broke a record made in October, 1943. At the same time employees of Ohio Works at Youngstown climbed above their record output of steel made two months previously.

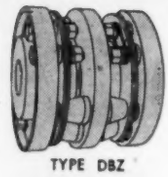
At the same time rolling mill departments of company plants did their share of record breaking by establishing 14 new unit marks.

HOT STRIP RECORD FOR WHEELING STEEL

▲ Wheeling Steel Corporation recently announced a production figure for March of 109,763.3 net tons of coils and plate from its 66 in. hot strip mill at Steubenville, Ohio. This tonnage represents a new record for this mill, surpassing its previous record of 102,000 tons set some months ago, and providing the Steubenville plant with another outstanding war production achievement to accompany the many departmental records set during the entire first quarter.

THOMAS
Flexible COUPLINGS

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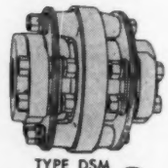
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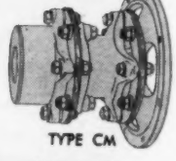
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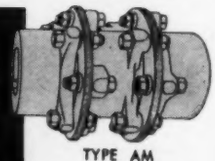
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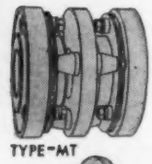
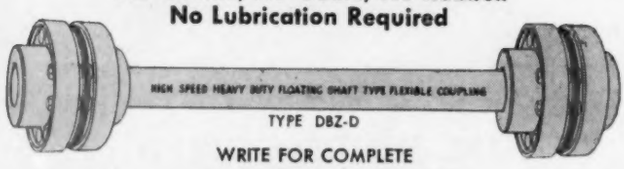
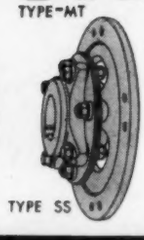

TYPE-MT

Eliminate BACKLASH, FRICTION, WEAR AND CROSS-PULL
the four destructive evils of other types and makes of couplings that prevent a permanent care-free installation.

The Thomas All-Metal Coupling has:
No Chains, No Gears, No Rubber.
No Lubrication Required



TYPE DBZ-D


TYPE SS

WRITE FOR COMPLETE ENGINEERING CATALOG

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

New Literature

▲ Bulletin No. 92, just released by The C. O. Bartlett and Snow Company, Cleveland 5, Ohio, describes the company's new plug feed type skip hoist loading gate. The bulletin has "progress photographs" showing how arms on the skip bucket release a latch on the gate, permitting the self-damming feed chute to be lowered into the position on rollers — and returned to latched position when the skip bucket is raised — avoiding friction — and wear — noise and spillage, even with quite high speeds of bucket travel. The folder is complete with detailed engineering diagrams and a table giving the dimensions of eleven standard sizes. Free on request.

▲ Number 1, Volume 1 of "Fasteners," published by the American Institute of Bolt, Nut and Rivet Manufacturers, carries an announcement of a comprehensive research program inaugurated by the Institute to investigate various subjects of interest to manufacturers and users of bolts, nuts, rivets, screws, etc. The research will be carried on at the Technological Institute of Northwestern University, and will do much to broaden service to users of fasteners.

The first issue of "Fasteners" also carries four articles dealing with bolts, nuts and rivets, as well as tentative specifications for cold riveted construction and a digest of current literature on fasteners. "Fasteners" will be sent regularly at no cost to users of bolts, nuts, rivets and screws upon request to the American Institute of Bolt, Nut and Rivet Manufacturers, 1550 Hanna Building, Cleveland 15, Ohio.

▲ The second edition of Industrial Combustion Data has just been published by Hauck Manufacturing Company, Brooklyn, New York. Data contained in the first edition of this book has been expanded and revised to include information on the latest developments and improvements in the combustion of oil and gas. Contents of the book include definitions of technical terms, data on oil burning, data on gas burning, and general industrial heating data. Information on pertinent Hauck equipment is incorporated into the text.

▲ Farrel-Birmingham Company, Inc., of Ansonia, Connecticut and Buffalo, New York, has released a new eight-page bulletin describing Farrel Manger couplings.

These couplings are designed for applications where space limitations make a close-coupled connection necessary or desirable. By bolting the coupling flange directly to a flywheel, brake drum or similar component, complete flexibility is provided between driving and driven units in half the space occupied by an ordinary coupling. And, in addition, no dummy, pilot or stub shaft is required. The Manger coupling is simple in construction, easy to install and align, and requires practically no maintenance.

The new bulletin includes engineering details, application diagrams and tables of sizes, ratings and dimensions.

▲ Broad possibilities of further relief to the problem of manpower shortage are forecast in the extended campaign being conducted by The Elwell-Parker Electric Company, Cleveland, Ohio, to train women in the operation of power industrial trucks.

A survey of 800 industrial executives two or three years ago revealed that more than half of them were interested in employing women to replace the men who were operating their industrial trucks. Elwell-Parker made this transition easy by preparing an instruction folder, "Lady, Will You Give a Lift?" to help customers to train women operators. This manual explained to the new operator the importance of her job and told her in non-technical language how to operate her truck and to take care of it.

The observed effect of this project was a sharp reduction in the time required for the average woman worker to learn to operate her truck properly and with confidence. With the help of the manual women can be taught to drive an industrial truck in one day, instead of the four or five days often consumed in hit-or-miss instruction. In the light of continuing pressure for the release of more men and for the production of more war materials,

Ampco screw down nuts, usually made by the centrifugal casting process, are available in sizes up to several thousand pounds.

Screw Down Nuts of Ampco Metal stand up

...where ordinary bronzes fail

AMPCO Metal

Reg. U.S. Pat. Off.

The Metal without an Equal

The strength and toughness of Ampco Metal enables it to stand up under the tremendous unit pressure transferred to the screw threads . . . This superior alloy of the aluminum bronze class is widely used for many other mill applications where impact strength or outstanding bearing qualities are required. Consult your nearest Ampco Field Engineer, or write for Engineering Data Sheets 38 and 73. AMPCO METAL, Inc., Dept. IS-4, Milwaukee 4, Wisconsin. Ampco Field Offices in all Principal Cities.

this training activity has loomed larger in importance from month to month. Accordingly the instruction manual, "Lady, Will You Give a Lift?" has been re-issued, this time in the form of a pocket-size booklet and with the addition of numerous new illustrations that were suggested after the first edition was circulated.

▲ Bulletin 32-33-B-12, covering rotary positive gas exhausters and boosters, has just been issued by Roots-Connersville Blower Corporation of Connersville, Indiana. This booklet is sixteen pages and cover, printed in two colors, and very profusely illustrated.

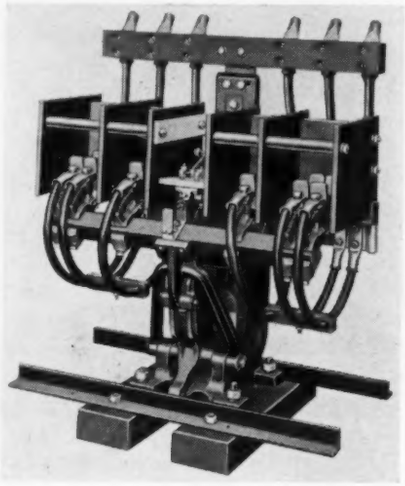
There is a total of fifty cuts, mostly halftones, but including a number of curves, diagrams, cross-sections, etc. The foreword traces the inception of the two-impeller displacement principle by the Roots brothers about 1854, showing the various adaptations to which machines of this type have been put through the intervening years. Advantages claimed by the manufacturer for this type of equipment are discussed, along with sections devoted to the operation principle, features of design and construction, and efficiency curves.

Special emphasis is laid on correctly designed gears, and there are three types illustrated and discussed at some length, including a multiple contact spur gear on which Roots-Connersville holds patents. All gears are cut in the company's own plants.

Much space is given to illustrations of typical installations and applications, as well as cuts of units adapted to higher speed operation. There are two pages devoted to special applications and compound units, and the booklet concludes with a discussion of some regulatory devices and a table of standard sizes.

Copies of this bulletin may be had by writing to the main office at Connersville, Indiana, or to any branch office.

▲ Bulletin 1062-C of the Electric Controller and Manufacturing Company, Cleveland, Ohio, describes the company's new type ZHS starters for full voltage starting of 2300, 4150 and 4600 volt motors. These starters are a complete revision of equipment previously manufactured for this service and are available in three ratings: moderate interrupting capacity (10 times full load motor current), 25,000 kva interrupting capacity and 50,000 kva interrupting capacity. They are supplied in a variety of enclosures. All of the starters have self-contained adjustable overload relays with inverse time element feature which protects motors from overheating due to overload, loss of one phase or failure to start.



▲ A new, eleven page bulletin has just been released by Whiting Corporation, Harvey, Illinois dealing with the collection and suppression of dust in industrial plants. This publication, known as "Practical Pointers on Dust Suppression," features the uses and application of Hydro-Clone dust suppressors. Charts and tables are used throughout for illustration, and they furnish the reader with much valuable information. Free copies of this bulletin will be mailed upon request.

▲ A new catalog, No. 2010-A, on Cleveland Steel-weld bending presses has just been issued by The Cleveland Crane and Engineering Company, Wickliffe, Ohio.

Highly illustrated, the catalog has many photographs of varied work being performed and covers many of the details of construction. A complete table of sizes and dimensions is included.

Detailed data is also given on Cleveland Steel-weld bulldozers along with dimensions and data on the most popular sizes.

Catalog No. 2010-A will be sent free upon request.

▲ For quick installation in war plants, shipyards, hospitals, and similar applications, Power Centers — compact, coordinated unit substations available in all standard ratings — are discussed in a new booklet announced by Westinghouse Electric and Manufacturing Company.

The new 25-page booklet contains a timesaving guide to the selection and specification of indoor and outdoor transformer installations, including coordinated disconnect and protective equipment. Standard arrangements are suggested to fit the various types of distribution systems.

Factory-assembled and tested, power centers combine all transformer and switching material in one unit. They save time, labor and critical materials. With this booklet, complete substations can be selected that will require no additional parts or protective vaults. Other advantages listed in the booklet are minimum space requirements, and added safety.

A copy of the new booklet (B-3224) may be secured from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

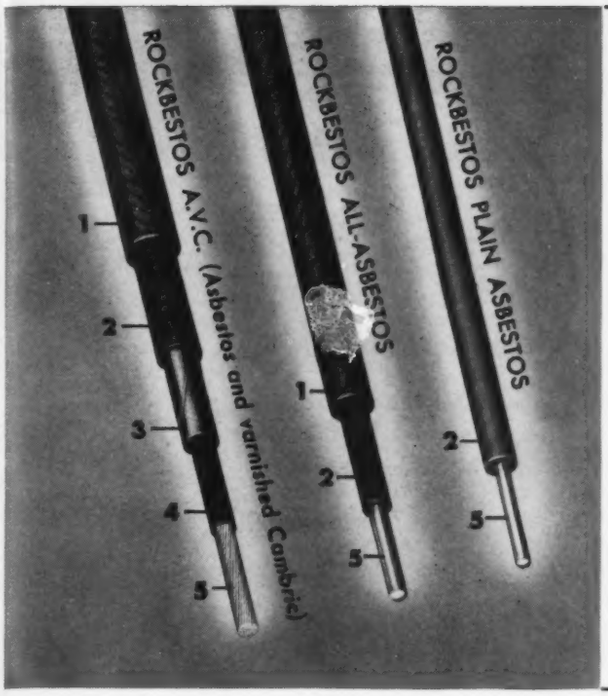
▲ To show some recent installations of its full-metered system of combustion control, the Leeds and Northrup Company has issued a revised Metermax catalog.

Embodying, in this thirty-seven page edition, basically the same engineering descriptions as were presented in the earlier 1939 publication, the present book presents in special photographic form illustrations of the various features of design which are said to contribute to the equipment's reliability.

This publication will be of special interest to anyone in central station or large industrial power plant, who may desire information concerning more recent installations.

For a copy, write to Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pennsylvania. Ask for Catalog N-01M-163.

▲ R. E. Uptegraff Manufacturing Company has issued a new 32-page catalogue, bulletin No. 117, on Uptegraff current and potential transformers. Illustrated from photographs are the various types and drawings together with mechanical data and prices. A copy of this new bulletin No. 117 may be had by addressing R. E. Uptegraff Manufacturing Company, Scottdale, Pennsylvania.



3 GETS YOU 122

122 wires, cables and cords, stemming from the three basic designs illustrated, have been developed by Rockbestos to give trouble-free performance under severe operating conditions in steel mills, power plants, chemical industries, etc. Send for catalog to see the rest.

Rockbestos Permanent Insulation Insures Long-Lived Performance

1. A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.
2. Felted asbestos insulation impregnated with heat-, flame-, and moisture-resisting compounds will not dry out, become hard and brittle, or burn. Also serves as a heat-barrier against high ambient temperatures.
3. Lubricated varnished cambric for high-dielectric strength and added moisture resistance, protected from heat, flame, and oxidation by felted asbestos walls.
4. Felted asbestos insulation that withstands conductor-heating overloads and won't burn even when exposed to copper-melting arcs.
5. The conductor is perfectly centered in helically applied insulation and will always remain so.

600 VOLT A.V.C. SWITCHBOARD WIRE—TABLE B

(Underwriters' Type AVB)

Sizes No. 18 to 4/0 A. W. G. with varnished cambric and felted asbestos insulation and gray, black, white or colored flameproof cotton braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is absolutely fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A. V. C. Hinge Cable and Switchboard Bus Cable have the same fireproof and heatproof characteristics.

INDUSTRIAL HEATING CABLE—TABLE LH

No. 19 A. W. G. nickel-chromium wire insulated with .040" of felted asbestos and covered with 4/64" waterproof lead sheath.

This pliable cable distributes a mild heat evenly over a large area. Prevents freezing of water pipes, wet pipe sprinkler systems, etc. Keeps conveyor pipes for fuel oil, soap, varnish, ink, chocolate, etc., at temperatures that insure steady flow.

ASBESTOS INSULATED MAGNET WIRE

Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and coil treatment requirements.

Protect your motors against heat-induced breakdowns with class B windings of Rockbestos Heat-Resisting Magnet Wire. Leads of A. V. C. Motor Lead Cable will complete the failure-proofing.

ALL-ASBESTOS FLEXIBLE CORD—TABLE CA

Sizes No. 10 to 18 A. W. G. with two or three conductors insulated with felted asbestos, covered with asbestos braid. Also in A. V. C. (asbestos and varnished cambric) constructions.

This heat-resisting flexible cord is ideal for high-wattage lighting units, floodlights, blueprint machines, apparatus, etc., which require a heavy duty, enduring cord. For moisture-resistant construction specify the A. V. C. type. Labeled cord with polarized conductors if desired.

600 VOLT A.V.C. BOILER ROOM WIRE—TABLE C

(Underwriters' Type AVA)

Sizes No. 18 to 4/0 A. W. G. This construction for sizes 18 to 8, sizes 6 to 4/0 have another wall of felted asbestos next to the conductor.

For lighting and control circuits exposed to heat and moisture, oil, grease, corrosive fumes or fire hazard, such as exist around furnaces, ovens, lehrs, soaking pits, boilers, etc., this widely used A. V. C. construction is ideal. Also for locomotive panel wiring and for switchboards requiring an asbestos braided wire.

THERMOSTAT CONTROL WIRE—TABLE TC

Sizes No. 14, 16 and 18 A. W. G. in two to six conductors with 12½, 25 or 31 mil wall of felted asbestos insulation and cadmium plated steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its lifetime insulation and rugged steel armor will give you trouble-proof circuits.

600 VOLT ALL-ASBESTOS RHEOSTAT CABLE—TABLE R

(Underwriters' Type AI)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with a heavy wall of felted asbestos, covered with a rugged asbestos braid finished in black, white or colors.

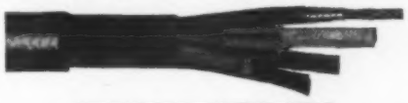
Use this power and rheostat cable for wiring rheostats, switchboards, elevator and locomotive control panels and electrical equipment exposed to heat, fumes and fire hazard. Also for general open wiring in dry, high temperature locations. For solid conductor specify Rockbestos Rheostat Wire, Table A.

600 VOLT A.V.C. MOTOR LEAD CABLE—TABLE L

(Underwriters' Type AVA)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with two walls of felted asbestos and a high-dielectric, heat-sealed varnished cambric insert, covered with heavy asbestos braid.

Heatproof, fireproof, greaseproof and oilproof, will not dry out and crack, won't burn or carry flame, and remains permanently flexible. For coil connections, motor and transformer leads where extreme heat and fire hazards are encountered as in steel mills, etc.



600 VOLT A.V.C. CONTROL CABLE

In one to 19 conductors. Standard stranding A. W. G. No. 12—19/No. 25 and No. 9—19/No. 22. Other strandings furnished.

Designed for use under conditions too severe for control cables with other types of insulation which deteriorate rapidly when exposed to high temperatures. Operates without failure under the attack of heat, oil, grease or corrosive fumes and may be installed in conduit as it has ample moisture resistance.

600 VOLT A.V.C. POWER CABLE—TABLE E

(Underwriters' Type AVA)

Sizes No. 18 A. W. G. to 1,000,000 CM insulated with laminated felted asbestos, varnished cambric, and asbestos braid. Other constructions for service voltages to 8000.

Recommended for power circuits and hot spot wiring in or around boiler rooms, steam tunnels, soaking pits, tenter frames, glass plants, etc. The asbestos and heat-sealed varnished cambric construction has ample moisture resistance and withstands high temperatures.

Rockbestos Products Corporation, 937 Nicoll Street, New Haven, Conn.

WON'T bake brittle, bloom, burn or rot— RESISTS heat, moisture, oil, grease and fumes

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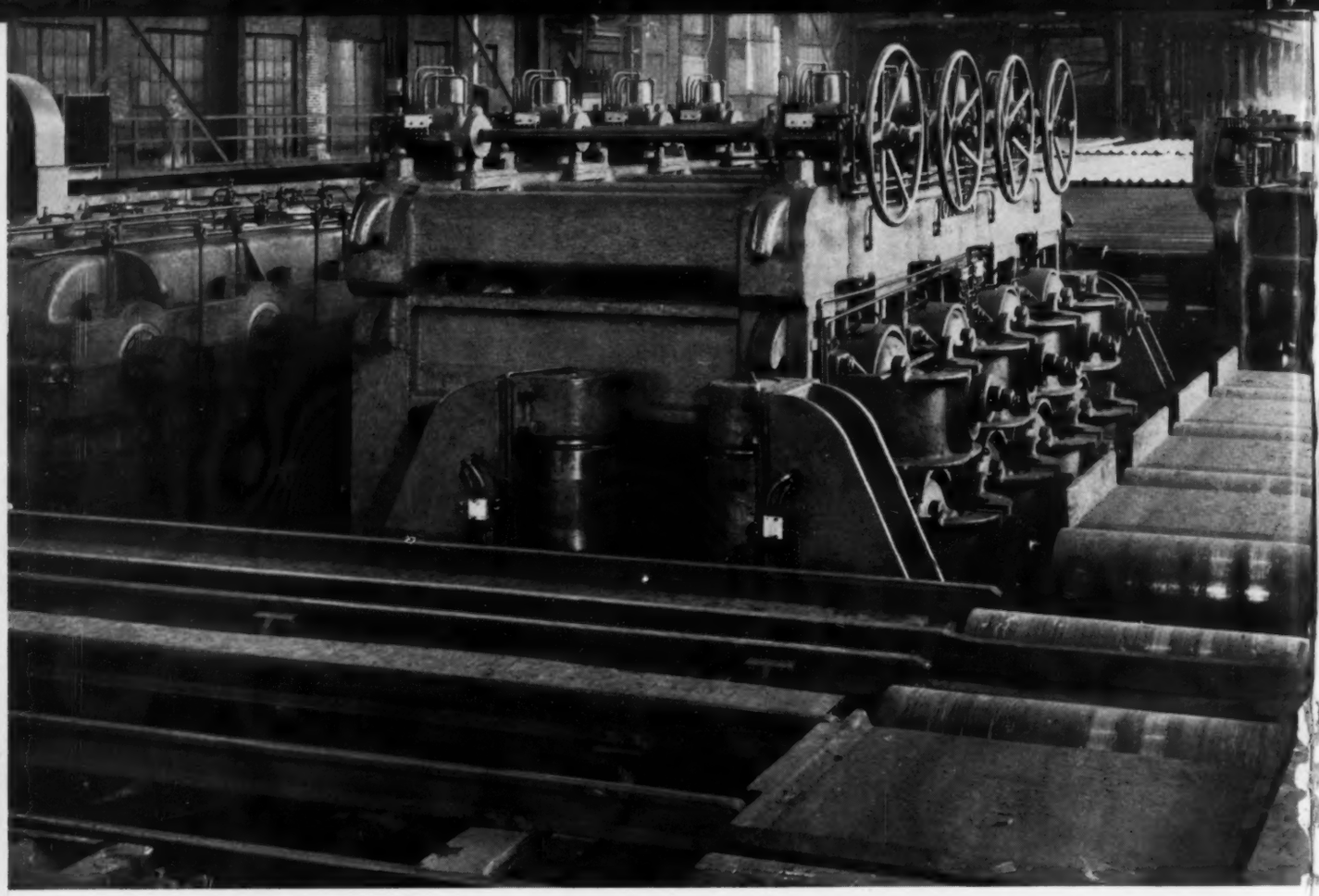
The Wire with Permanent Insulation



24″ I BEAM STRAIGHTENER

● Illustrated is a Morgan Roller Straightener for structural shapes up to 24″ I beams.

It is equipped with four top and four bottom rolls, all of which are adjustable. These eight rolls are arranged to be connected by spindles to a separate enclosed gear box drive. All gear shafts are mounted in roller bearings. Vertical rolls are provided on both entry and delivery sides.

A section of roller table is mounted on one side of straightener to be shifted into the roller table line when straightener is not in use.

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Throw Your Scrap Into the Fight

Personnel News

Oscar Seidel has been appointed manager of the structural fabricating division at the Ambridge plant of the American Bridge Company, U. S. Steel subsidiary. He succeeds the late David L. See.

Mr. Seidel has been general superintendent of the hull division at the company's Ambridge shipyard since February, 1943. He has been employed by American Bridge since his graduation from Penn State College with a degree of B.S. in Civil Engineering in 1915.

David Thomson has been elected president of the Phoenix Iron Company, Phoenixville, Pennsylvania, to fill the vacancy caused by the recent death of Samuel J. Reeves.

E. F. Blank, director of personnel relations for Jones and Laughlin Steel Corporation, Pittsburgh, has been appointed substitute industry member of the National War Labor Board. Mr. Blank, who has been associated with the steel industry for the past 18 years, is past president of the Pittsburgh Personnel Association. He has been industry member of the Third Regional War Labor Board in Philadelphia for more than a year. Mr. Blank resigned his position with the Regional Board to accept the appointment with the National Board.

Joseph L. Block has been made deputy director of the Steel Division, War Production Board, it was announced recently.

Mr. Block, who is on leave of absence as executive vice-president of the Inland Steel Company, Chicago, has been with the Steel Division for more than two years. Since July, 1943, he has served as assistant director of the Steel Division.

W. E. Bisler, recently district manager for Pomona Pump Company at Pittsburgh and formerly many years with Combustion Engineering Company, is now serving as industrial engineer for Dowell Incorporated. Mr. Bisler is attached to the New York office of Dowell, a subsidiary of The Dow Chemical Company. Mr. Bisler's long experience in the power industry fits him particularly well for Dowell's Industrial Chemical Service.

Al J. McCullough and **Jack E. MacConville** have been placed in joint charge of industrial instrument sales for the Brown Instrument Division of the Minneapolis-Honeywell Regulator Company at its Cleveland, Ohio, office.

Mr. McCullough has been with the Cleveland branch for the past eight years. Mr. MacConville has been with the Brown division for the past 15 years, most of that period having been spent in the sales department at the Philadelphia home plant of the Brown organization. Both appointments became effective April 1.

George H. Rose, formerly chief engineer of the American Steel and Wire Company, has been advanced to the position of assistant to the vice-president. He has been active in the engineering field for 40 years, 37 of which have been with American Steel and Wire.

GEORGE H. ROSE PURDY PIX

Following his graduation from Case School of Applied Science, in Cleveland, Mr. Rose served as a draftsman with the Cleveland Crane and Engineering Company from 1902 until 1903, when he became associated with Wellman-Seaver-Morgan Company. He also was employed with the Willard Storage Battery Company and the Jeffery Manufacturing Company of Columbus before joining American Steel and Wire.

His first employment with the Wire Company was in 1905, when he began as a draftsman at the Newburgh Steel Works in Cleveland. He had been promoted to chief draftsman at Newburgh, before being transferred to Pittsburgh as an engineer in 1917. In 1922, he was appointed assistant construction engineer at Pittsburgh, and four years later was transferred back to Cleveland in the same capacity. The following year he became construction engineer of the Wire Company and in 1937 was appointed chief engineer.

Born in Wellsville, Ohio, Mr. Rose attended the township school and the high school at Wooster before matriculating at Case, from which he was graduated with a B.S. degree in mechanical engineering.

E. J. Reardon, formerly assistant chief engineer, is now chief engineer.

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NON-FLUID OIL does not separate or leave harmful non-lubricating residues to clog fittings and bearings like ordinary greases. Being all lubricant, it works dependably until entirely consumed, lasts longer, requires less frequent application.

For ball and roller bearings lubricated by pressure systems NON-FLUID OIL has the added advantage of being strictly neutral. Recommended and used by all leading manufacturers of anti-friction bearings.

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TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT OFFICE & FOREIGN COUNTRIES

Modern Steel Mill Lubricant

Better Lubrication at Less Cost per Month

W. R. Swoish has been appointed sales manager of the Pennsylvania Transformer Company.

A graduate of Ohio State University in electrical engineering, Mr. Swoish has had wide experience in the electrical industry. He was sales manager of both distribution transformer section and the switchgear division at Westinghouse. He was affiliated with the

W. R. SWOISH

Roller-Smith Company as sales manager from 1939 to 1943. Mr. Swoish spent a short time in the Cleveland office of Allis-Chalmers before joining the Pennsylvania Transformer Company.

Mr. Swoish's new headquarters will be at the company's main offices in Pittsburgh. He will have full charge of all sales activities.

Harold E. Strang, for the past three years engineer of General Electric's Philadelphia Works, has been named to the staff of H. A. Winne, vice-president in charge of design engineering, apparatus department, it has been announced by the company. Mr. Strang, whose appointment became effective April 1, will be located in Schenectady.

A native of Mechanicville, New York, he was graduated in 1922 with a B.S. degree in electrical engineering at Rensselaer Polytechnic Institute, and that same year joined General Electric as a test engineer at the Schenectady Works. He became acquainted with switchgear through tests assigned to him, and shortly was placed in charge of switchboard tests.

Mr. Strang next became a member of the switchboard engineering department, transferring to Philadelphia in 1929 as an application engineer. In 1932 he was promoted to managing engineer of the Large Power Circuit Breaker Division, and on October 1, 1940, was named engineer of the Philadelphia Works.

E. G. Bailey, president and founder of the Bailey Meter Company was elected chairman. **Robert S. Coffin** succeeds him as president.

Mr. Coffin, who has been vice-president since 1925, became identified with Bailey Meter Company as treasurer at the time of its organization in 1916.

Other officers elected are: **R. E. Woolley,** vice-president, who has served in that capacity since 1927, and **J. H. Black,** secretary-treasurer.

N. A. Fitch has been appointed vice-president of the National Steel Products Company, Houston, Texas, it was announced recently. National Steel Products Company is a subsidiary of National Steel Corporation.

Mr. Fitch had been general manager of National Steel Products Company from its organization in 1939. He has been connected with steel warehousing distribution over a period of many years in the Southwest where he is widely known.

W. A. Gormley was recently appointed sales manager of the valve department of American Car and Foundry Company. He has been actively engaged in the valve field for more than 20 years.

He attended Duquesne University's School of accounts of finance and commerce, graduating with a

W. A. GORMLEY

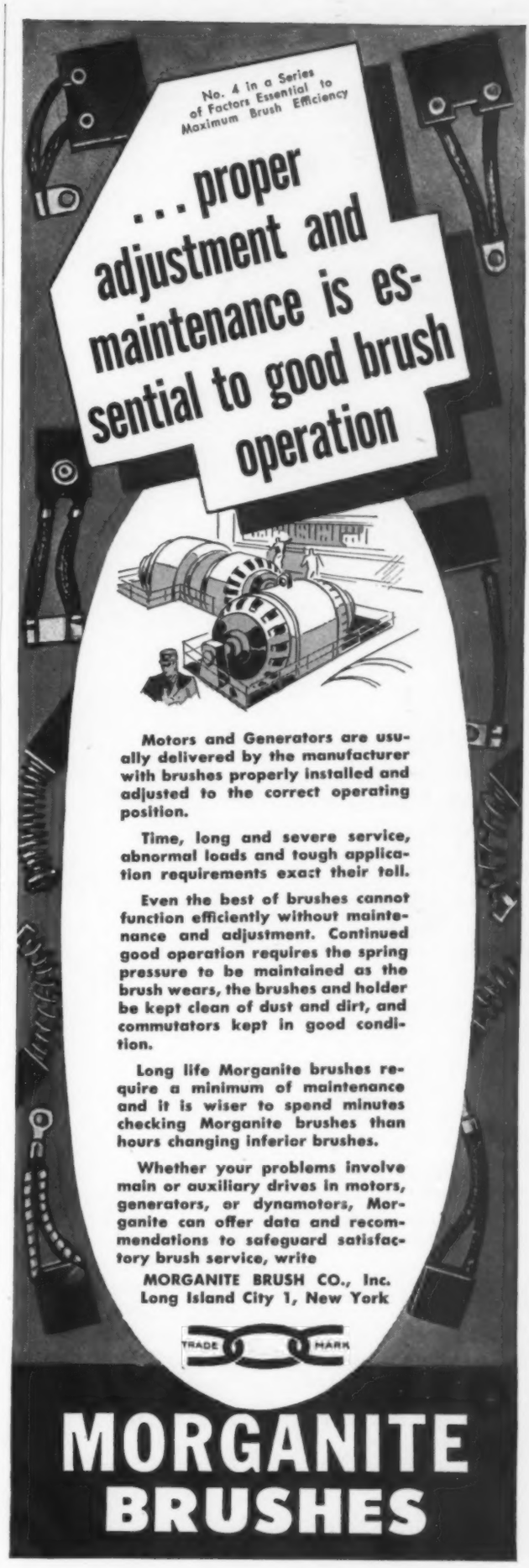
B.C.S. degree. In 1923, he organized and was co-owner of the Eastern Steam Specialty Company of New York City, manufacturing agents handling plug valves and engineering specialties, remaining there until 1935 when he came to A. C. F.

L. A. Bedard, formerly associated with Mt. Vernon Car Manufacturing Company, has been appointed sales agent for American Car and Foundry Company with headquarters at the A. C. F. St. Louis sales office.

Mr. Bedard was born in St. Louis, Missouri. He attended high school in Mt. Vernon, Illinois and was graduated in 1916 from Purdue University with the degree of mechanical engineer.

His first job was with the Mt. Vernon Car Manufacturing Company, where he held various positions in the engineering department until finally he was made assistant mechanical engineer. In 1936 he transferred to the sales department and in 1937 was made manager of sales which position he held until his recent appointment to the St. Louis office of American Car and Foundry Company.

In addition to his sales work, for the past three years he was in charge of both the grey iron and wheel foundries of the Mt. Vernon company.


No. 4 In a Series of Factors Essential to Maximum Brush Efficiency
. . . proper adjustment and maintenance is essential to good brush operation
Motors and Generators are usually delivered by the manufacturer with brushes properly installed and adjusted to the correct operating position.
Time, long and severe service, abnormal loads and tough application requirements exact their toll.
Even the best of brushes cannot function efficiently without maintenance and adjustment. Continued good operation requires the spring pressure to be maintained as the brush wears, the brushes and holder be kept clean of dust and dirt, and commutators kept in good condition.
Long life Morganite brushes require a minimum of maintenance and it is wiser to spend minutes checking Morganite brushes than hours changing inferior brushes.
Whether your problems involve main or auxiliary drives in motors, generators, or dynamotors, Morganite can offer data and recommendations to safeguard satisfactory brush service, write
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BRUSHES

E. B. Winning has been appointed assistant to the vice-president in charge of operations of Republic Steel Corporation.

Mr. Winning, who has been manager of the company's northern coal mines since 1933, will have supervision over all of Republic's mining operations. He will move his headquarters from Uniontown, Pennsylvania,

E. B. WINNING

to Cleveland, and will be succeeded as district manager by **J. L. Hamilton,** now assistant district manager.

Born in Industry, Pennsylvania, Mr. Winning was first employed by Westinghouse Electric and Manufacturing Company of East Pittsburgh, where he attended the Westinghouse Technical School and took its apprentice training. Two and one-half years later he joined the Pittsburgh Coal Company as a miner and later had charge of the company's electrical and mechanical work.

In 1914 he went with the United Coal Corporation as general master mechanic and two years later joined Republic Iron and Steel Company in its Pennsylvania mines as electrical and mechanical engineer. He was appointed assistant district manager in 1932 and district manager in 1933.

Mr. Hamilton, who succeeds Mr. Winning, was born in Scottdale, Pennsylvania, and had his first position with H. C. Frick Coke Company in the engineering department. From 1923 to 1934 he was employed by the Buckeye Coal Company in the engineering, safety and operating departments and during that time completed a course in mining given by the Pennsylvania State College where he later taught evening classes for a number of years. He joined Republic in 1934 as safety engineer of the northern coal mines and was made supervisor of industrial relations in 1937 and assistant district manager in 1939.

Joseph H. Bennis has been elected president of the New York and New Jersey Lubricant Company, New York, to succeed **W. F. Kimball,** retired due to ill health.

Mr. Bennis has been associated with the company since its organization in 1896 and has been head of its sales department for over thirty years.

Dr. V. N. Krivobok, recognized authority on stainless steel and former professor of metallurgy at the Carnegie Institute of Technology for many years, has become associated with the development and research division of The International Nickel Company at New York.

Dr. Krivobok's services will be utilized mainly in the development of markets for alloy and stainless steels and to assist steel manufacturers in expanding markets for their post-war products.

Residing at present in Glendale, California, Dr. Krivobok had until recently been chief metallurgist of the Lockheed Aircraft Corporation at Burbank. Before joining Lockheed in January, 1941 he had been professor of metallurgy at Carnegie Institute of Technology since 1924 while also serving as associate director of research for the Allegheny Ludlum Steel Corporation (1934-1940). From 1924 to 1934 he had been consulting metallurgist to several steel companies.

James D. Ford has been appointed credit manager of the Weirton Steel Company to fill the vacancy created by the death of the late W. L. Horner, it was announced recently.

J. J. "Andy" Mellon, assistant sales manager of the Clark Controller Company has been elected a vice-president of this company. He was graduated from the Rensselaer Polytechnic Institute and has worked in the electrical utility field and in the steel mill division of a large electrical manufacturer. Mr. Mellon joined Clark in 1929.

J. J. MELLON

Paul L. Goldstrohm and **George M. Muschamp** have been elected members of the board of directors of the Brown Instrument Company, Philadelphia, manufacturer of precision industrial instruments. Mr. Muschamp is vice-president in charge of engineering of the Brown Company, a division of Minneapolis-Honeywell Regulator Company, and Mr. Goldstrohm is vice-president in charge of production.

C. H. Longfield, assistant director and chairman, production directive committee of the Steel Division, War Production Board, will assume the duties of **J. V.**

DEPENDABLE
PRODUCTION OF BARS,
TUBES AND SHAPES

BASIC
IN COUNTLESS WAR APPLICATIONS
TODAY—
EQUALLY IMPORTANT
IN YOUR POST-WAR REQUIREMENTS
TOMORROW!

The consistently smooth and trouble-free functioning of Vaughn Draw Benches . . . together with their remarkable endurance under the stress of war's mass production demands . . . are qualities from which sound conclusions can be drawn for your post-war planning . . . and for your eventual investment in equipment that pays dividends under tough competitive conditions!

THE VAUGHN MACHINERY COMPANY
Cuyahoga Falls, Ohio, U. S. A.

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DRAW BENCHES

COMPLETE COLD DRAWING EQUIPMENT
Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

OHIO
Extra Strength
MAGNETS

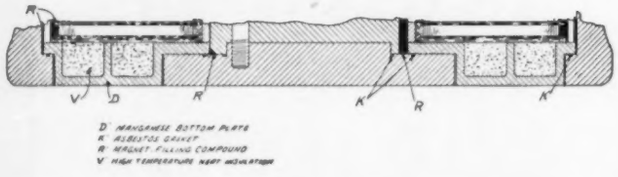
The OHIO 6 pancake coil magnets in the 55" and 65" diameters will average 35% better lifts than the standard magnets.

The OHIO 8 pancake coil magnets will average 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

Numerous repeat orders testify that performance equals or exceeds the statements above.

★When OHIO magnets are required to lift hot materials the heat resisting bottom construction shown below successfully retards the flow of heat from the load to the magnet coil and permits all day use.



D MANGANESE BOTTOM PLATE
K ASBESTOS GASKET
R MAGNET FILLING COMPOUND
V HIGH TEMPERATURE HEAT INSULATION

Have you a problem requiring fast lifting or lifting of hot steel?

The OHIO Electric Mfg. Co.

5907 Maurice Avenue Cleveland 4, Ohio

Honeycutt, assistant director for production, who has resigned to return to his former position with the Bethlehem Steel Company, Bethlehem, Pennsylvania.

Mr. Longfield has been with WPB for more than two years. He came here from the Youngstown Sheet and Tube Company, Youngstown, Ohio.

E. W. Potratz has been appointed as manager of the hoist sales division, Harnischfeger Corporation. His charges include the four classes of P&H hoists, Handi-Lift, Zip-Lift, Hevi-Lift, and Trav-Liftcranes. Mr. Potratz' association with the company has been marked by sound and rapid advancement, and coincides with many important product developments in the P&H line.

Since 1942, with the protracted illness of **George Drake,** he was acting sales manager. He joined the Harnischfeger hoist division as an estimator in 1935, and in 1939 was named assistant sales manager.

Prior to joining Harnischfeger, Mr. Potratz was employed in product engineering and development with several leading industrials in the middle west.

Benjamin "Ben" Van Horn recently retired after 47 years' association with Harnischfeger Corporation of Milwaukee. In his long career in the crane field, Mr. Van Horn found a perfect barometer of business conditions. Not only did he witness the development of the nucleus of mass production in industry, but by the behavior of the crane sales curve, he foresaw the trends to depressions and booms in the last half-century.

Joining Harnischfeger as a stenographer in 1896, the company then known as Pawling and Harnischfeger, from which name the present world-known P&H trademark is derived, he advanced into crane sales work by 1913, and rapidly rose to the position of sales manager.

Paul Keller and **E. B. Farris** have organized The Ohio Stainless Steel Company with offices at 1048 Union Commerce Building, Cleveland, to specialize in all types of stainless steel products, including bars, plates, special shapes, strip, sheets, wire and tubing. The company also will handle stainless-clad sheets and plate, as well as stainless and heat-resistant castings.

A number of companies producing stainless steel will be represented by the Ohio company in the central west including the Jessop Steel Company, Washington, Pennsylvania, the Joslyn Manufacturing and Supply Company, Chicago, the Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, and others.

Mr. Keller formerly was associated with the Copperweld Steel Company, Warren, Ohio, as sales manager of tool, stainless and special steels. Prior to joining the Copperweld Company, he represented the Bethlehem Steel Company at Cleveland in a sales capacity for a number of years.

Mr. Farris was assistant district sales manager at Cleveland for Copperweld and previously had been associated with Edgar T. Ward's Sons Company.

Cason Jewell Callaway of Hamilton, Georgia, has been elected a director of the United States Steel Corporation to fill the vacancy in the board created by the death last year of James A. Farrell.

Mr. Callaway was president, then chairman of the

board of directors of Callaway Mills of LaGrange, Georgia, from 1920 to 1938. Mr. Callaway retired in 1938 as the active head of Callaway Mills to enable him to devote his time to the development of additional profitable cash crops for the south.

Mr. Callaway was born at La Grange, Georgia, on November 6, 1894, and was educated at the University of Virginia.

Laurence O. Millard, Link-Belt district manager at Pittsburgh, has been advanced to the position of central-division manager for materials handling machinery, with headquarters at the company's Pershing Road plant in Chicago.

Mr. Millard joined the Chicago plant engineering department in 1913, and was transferred to the Cleveland office as sales engineer in 1923. In 1929, he returned to the Pershing Road plant, Chicago, as a specialist in power plant coal and ashes handling machinery applications. In 1933, he was appointed district manager at Cleveland; and in 1938, district manager at Pittsburgh, the position last held.

Rod S. Galloway, production engineer at the Pershing Road plant, Chicago, has been named district manager at Pittsburgh to succeed Mr. Millard.

Mr. Galloway, a mechanical engineering graduate from Iowa State College, 1927, started his Link-Belt career in 1928 in the engineering department of the Pershing Road plant, following shop experience in the locomotive shops of the Chicago and Great Western Railroad at Oelwein, Iowa.

He has successively served in the Link-Belt engineering estimating department; as district engineer in central division territory; and lastly as production engineer engaged in expediting production of work going through the Pershing Road plant.

C. S. Beattie, formerly manager of engineering of the Delta-Star Electric Company, Chicago, is now vice-president in charge of production and engineering. Joining the organization in 1930, he became assistant sales manager in 1936 and manager of engineering in 1941. Before association with Delta-Star he was with the Westinghouse Electric and Manufacturing Company, East Pittsburgh and the United Engineers and Constructors, Inc., Newark, New Jersey.

S. C. Killian, formerly development and research engineer, is now chief engineer. Entering the drafting department in 1923, he enrolled at the University of Michigan in 1930. Upon graduating he entered engineering practice and returned to Delta-Star's development department, becoming research and development engineer in 1941.

Thor Fjellstedt, now assistant chief engineer, came with Delta-Star in 1926 and has been a design engineer since 1930.

Manfred Stene, who started with the Delta-Star in 1924, and was formerly design engineer of the control section, is now electrical engineer.

R. A. Sternaman, came to Delta-Star in 1923. He was formerly design engineer of the switch mechanisms section and is now mechanical engineer.

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FLAT PARTS
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GENERAL PURPOSE MARKING MACHINE
Any desired lettering or design clearly and permanently marked on your products with this machine. Marks parts up to 6" in diameter or thickness. Furnished in hand operated, pneumatic and motorized models.
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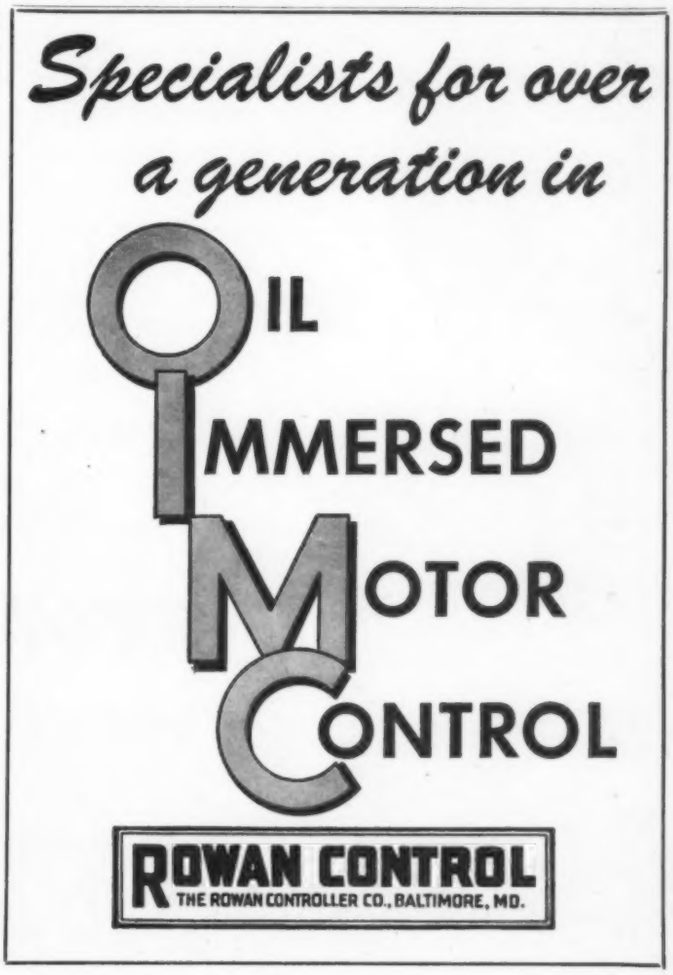


outward sign

OF INWARD BETTERMENT . . . IN MOTOR STARTERS

Point by Point . . .

WIDE, COORDINATED RANGE of stock units . . . from "TT" manual starters for small motors to complete multi-motor CONTROL CENTERS.

TRUMBULL-PIONEERED VERTICAL CONTACT design prevents dust and carbon troubles.

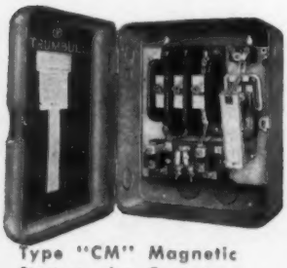
WIRING, INSPECTION, REMOVAL and REPLACEMENT of parts FROM THE FRONT saves installation and maintenance time.

COMPACT, SPACE-SAVING COMBINATIONS include starter and disconnect in same box.

"BUILDING-BLOCK SIMPLICITY" in laying out centralized multi-motor control installations with Trumbull "packaged" stock-unit-type MOTOR CONTROL CENTERS.

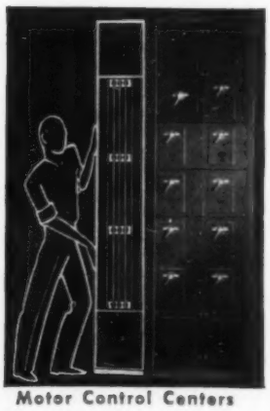
Type "TT" Manual Starter for small motors (1 hp max.)

Type "TM" Manual Starters "TM-2", 2 hp., "TM-7-½", 7-½ hp.



Type "CM" Magnetic Starters also Contactors Motor reversing

Combination Starters (Magnetic starter & disconnect)



Motor Control Centers

TRUMBULL

MOTOR STARTERS

• Whether you need a starter for a single small motor or a modern control center layout for an entire production line . . . look to Trumbull. We will be glad to send you Motor Control literature upon request. Ask for Bulletins 404 & 411.

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Accuracy gets a flying start

Every letter in the alphabet lines up for inspection in the typewritten sentence:
The quick brown fox jumps over the lazy dog
. . . Clicked off on key bars, which in turn are stamped accurately from thousands of miles of steel strip, rolled to uniform size and quality on Morgan Rolling Mills. Ultimate accuracy gets a flying start in a Morgan Mill.

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

***PLAN NOW WITH* MORGAN**

R-122

ENGINEERS AND BUILDERS OF ROLLING MILLS . . . WIRE MILLS . . .
GAS PRODUCER MACHINES . . . REGENERATIVE FURNACE CONTROL

The MOST PUMP in least Weight & Space
The DeLaval-IMO pump for fuel oil and "lube" oil services is distinguished by compactness and simplicity. There are only three working parts, which are in complete hydraulic and rotational balance and which propel the oil without pulsation, like a piston moving steadily forward. There are no valves, no gears, no cams and no reciprocating parts. The one packing is under suction pressure only and is easily accessible. Any quantity of oil is delivered against any pressure.
Ask for Publication I-111
IMO
I MOVE OIL
IMO PUMP DIVISION
of the De Laval Steam Turbine Company, Trenton, N. J.

William C. Johnson, James M. White and **William A. Roberts** have been elected vice-presidents of the Allis-Chalmers Manufacturing Company.

Mr. Johnson, who has been general sales manager, came to Allis-Chalmers in January, 1924. After serving in various district offices, he became sales manager of the crushing and cement division. Next, he was placed in charge of general sales in May, 1942, succeeding Mr. Geist, who became president. Mr. Johnson was born in Birmingham, Alabama.

Mr. White was born in River Falls, Alabama. He came to Allis-Chalmers in 1929 after graduating from the Albama Polytechnical Institute. Completing the company's training course for graduate engineers, Mr. White became a "trouble shooter" on shop and field jobs. In 1934, he was made manager of the company's La Porte, Indiana works. He returned to Milwaukee in 1941 to become assistant general works manager, and was elevated to works manager in April, 1942.

Mr. Roberts, who was born on a farm near Osceola, Missouri, came to Allis-Chalmers as a salesman after varied experience as a road contractor and salesman. He progressed until he was Canadian representative and then for a time operated his own agency at Regina, Saskatchewan. In June, 1930, he returned to Milwaukee as agricultural sales manager of the company's tractor division, and in 1941 he succeeded the late Harry C. Merritt as manager of the tractor division.

Russell D. Yoder has been appointed sales engineer in charge of the new Columbus, Ohio sales office of Cutler-Hammer, Inc., Milwaukee. The new office is located at the Chamber of Commerce Building, 30 East Broad Street, Columbus 15.

Mr. Yoder is a graduate of Case University, E.E. 1939, and has had a thorough training and experience in the application, selection, and analysis of the products manufactured by his company.

Trained at Milwaukee headquarters, Mr. Yoder completed the company's student engineer course after which he worked in the engineering and resale sales departments. In 1941 he went to Cincinnati district office where he worked as estimator, application engineer, and sales engineer before establishing the Columbus office.

The territory of the new Columbus office includes 25 counties in central and eastern Ohio. For the present, the Columbus office will operate as a branch of the Cincinnati district sales office of which **E. C. Bolton** is district manager.

Soren H. Mortensen, chief electrical engineer for Allis-Chalmers Manufacturing Company, Milwaukee, was recently awarded an honorary Doctor of Engineering degree by Illinois Institute of Technology at Chicago "for distinguished leadership in the development of alternating current machinery."

F. C. Schoen was recently appointed plant engineer for The Midvale Company, Philadelphia, Pennsylvania. Mr. Schoen graduated from Case School of Applied Science in Cleveland, Ohio, and entered the employ of the General Electric Company as a student engineer. He then moved in 1933 to Republic Steel Corporation where he became electrical maintenance foreman. In

1938 he transferred to the Midvale Company, taking the position of assistant to plant engineer and progressively advancing through assistant master mechanic and master mechanic to his new position.

An organization meeting of the newly appointed industry advisory committee of eight representatives of manufacturers of rolling mill machinery and equipment will be held in the near future, the Office of Price Administration announced recently.

Members appointed to the committee to meet with and advise OPA on pricing problems arising within the industry are:

G. N. Herman, vice-president, Continental Foundry & Machine Company, East Chicago, Indiana; **Q. S. Snyder,** president, Pittsburgh Rolls Division of Blaw-Knox Company, Pittsburgh, Pennsylvania; **J. R. Patterson,** vice-president, Mackintosh-Hemphill Company, Pittsburgh, Pennsylvania; **J. L. Campbell,** sales manager, The Ohio Steel Foundry Company, Lima, Ohio; **B. G. Parker,** president and general manager, The Youngstown Foundry and Machine Company, Youngstown, Ohio; **L. W. Nash,** manager, E. W. Bliss Company, Salem, Ohio; **R. A. Cannon,** vice-president, Birdsboro Steel Foundry and Machine Company, Birdsboro, Pennsylvania; **G. R. Casey,** president, Treadwell Engineering Company, Easton, Pennsylvania.

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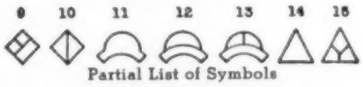

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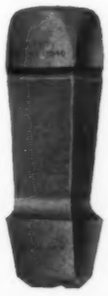

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Obituaries

J. "Jake" M. Faris, well-known pioneer in the Mahoning valley steel industry, died March 31st in Youngstown, Ohio. Mr. Faris entered the steel business in 1893 as a mechanic, working for James A. Campbell, then superintendent of the Pomeroy (Ohio) Rolling Mill Company. This association held until Mr. Campbell's death, and when the latter came to Youngstown in 1896 as superintendent of the old Valley mill, Mr. Faris accompanied him as master mechanic. With the formation of Youngstown Sheet and Tube Company in 1900, Mr. Faris was made superintendent of the electrical and mechanical departments, holding that position throughout the construction and expansion of the company. In 1928 he was appointed assistant to the vice-president and in 1935 special consulting engineer, occupying this position until his retirement from active service in 1937.

J. M. FARIS

Frank B. Wilkinson, retired industrialist and founder of Logansport Machine Company, Inc., died at his home in Logansport, Indiana, on March 23, after a lingering illness.

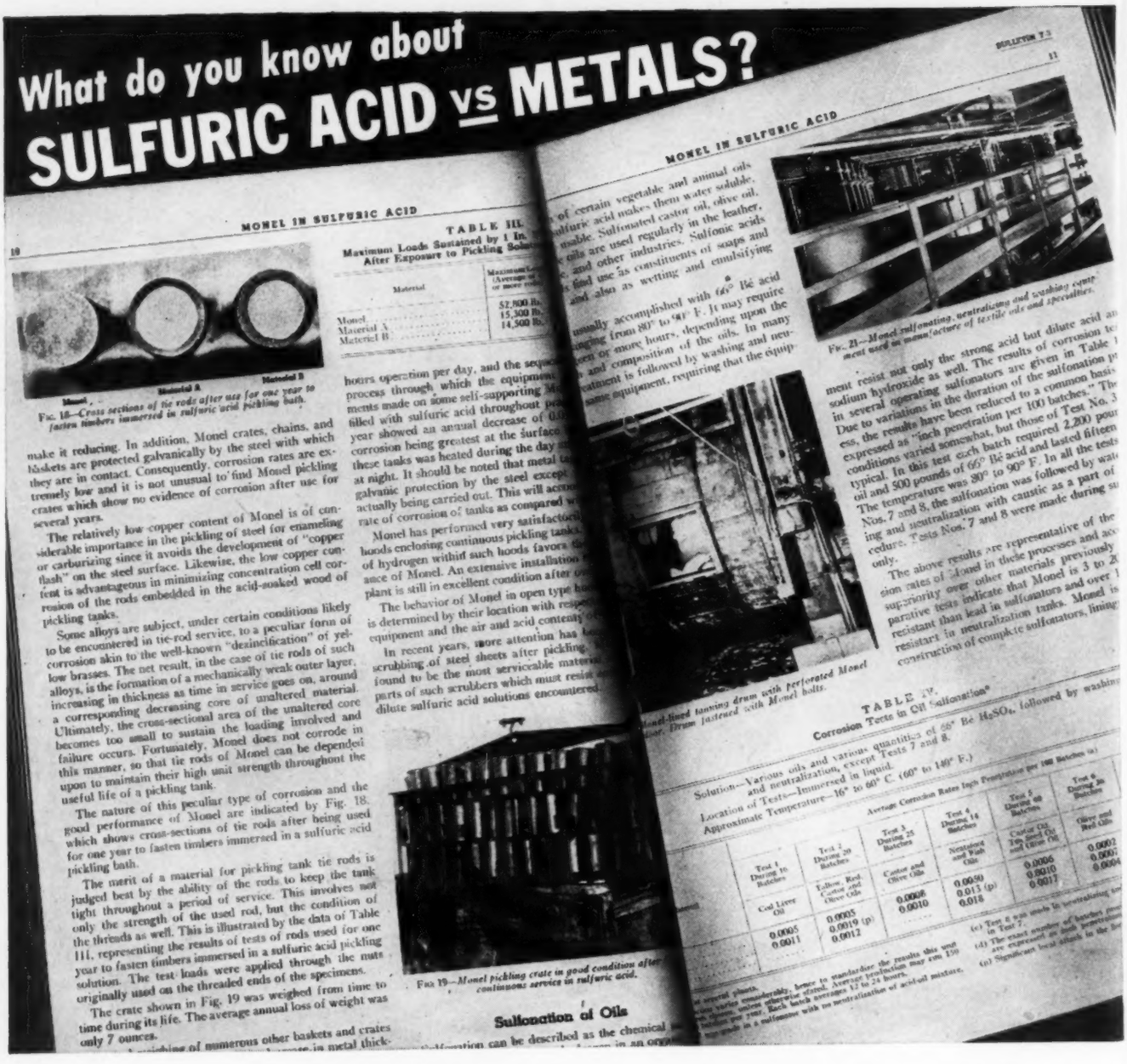
Born in Belmont County, Ohio, in 1856, Mr. Wilkinson had been a resident of Logansport for forty-four years, where he was instrumental in the founding of several other manufacturing companies in addition to the Logansport Machine Company, Inc., the one with which he was most prominently identified.

In 1916 he formed the Logansport Machine Company, Inc., to manufacture air and hydraulic operated equipment. The growth of the business twice made increased space necessary, and in 1929 the company acquired the present plant location. Mr. Wilkinson had not been active in the business for several years.

James J. Zimmerman, 53, Follansbee Steel development engineer, died recently.

Born in Johnstown on July 29, 1890, Mr. Zimmerman attended the Johnstown public schools and was a graduate of Bethlehem Preparatory School. He was certified to Lehigh College and studied at Pennsylvania State College. He graduated in accounting from the International Business Machine School at Endicott, New York.

What do you know about SULFURIC ACID vs METALS?



MONEL IN SULFURIC ACID

TABLE III.
Maximum Loads Sustained by 1 In. After Exposure to Pickling Solu

Material	Maximum Load (Average of 3 or more tests)
Monel	52,800 lb.
Material A	15,300 lb.
Material B	14,500 lb.

Monel Material A Material B

FIG. 18—*Cross sections of tie rods after use for one year to fasten timbers immersed in sulfuric acid pickling bath.*

make it reducing. In addition, Monel crates, chains, and baskets are protected galvanically by the steel with which they are in contact. Consequently, corrosion rates are extremely low and it is not unusual to find Monel pickling crates which show no evidence of corrosion after use for several years.

The relatively low copper content of Monel is of considerable importance in the pickling of steel for enameling or carburizing since it avoids the development of "copper flash" on the steel surface. Likewise, the low copper content is advantageous in minimizing concentration cell corrosion of the rods embedded in the acid-soaked wood of pickling tanks.

Some alloys are subject, under certain conditions likely to be encountered in tie-rod service, to a peculiar form of corrosion akin to the well-known "dezincification" of yellow brasses. The net result, in the case of tie rods of such alloys, is the formation of a mechanically weak outer layer, increasing in thickness as time in service goes on, around a corresponding decreasing core of unaltered material. Ultimately, the cross-sectional area of the unaltered core becomes too small to sustain the loading involved and failure occurs. Fortunately, Monel does not corrode in this manner, so that tie rods of Monel can be dependest upon to maintain their high unit strength throughout the useful life of a pickling tank.

The nature of this peculiar type of corrosion and the good performance of Monel are indicated by Fig. 18, which shows cross-sections of tie rods after being used for one year to fasten timbers immersed in a sulfuric acid pickling bath.

The merit of a material for pickling tank tie rods is judged best by the ability of the rods to keep the tank tight throughout a period of service. This involves not only the strength of the used rod, but the condition of the threads as well. This is illustrated by the data of Table III, representing the results of tests of rods used for one year to fasten timbers immersed in a sulfuric acid pickling solution. The test loads were applied through the nuts originally used on the threaded ends of the specimens.

The crate shown in Fig. 19 was weighed from time to time during its life. The average annual loss of weight was only 7 ounces.

hours operation per day, and the sequ process through which the equipme ments made on some self-supporting M filled with sulfuric acid throughout pe year showed an annual decrease of 0.0 corrosion being greatest at the surface these tanks was heated during the day at night. It should be noted that metal t galvanic protection by the steel except actually being carried out. This will acco rate of corrosion of tanks as compared w

Monel has performed very satisfactori hoods enclosing continuous pickling tanks of hydrogen withit such hoods favora ance of Monel. An extensive installation plant is still in excellent condition after o

The behavior of Monel in open type h is determined by their location with respe equipment and the air and acid content

In recent years, more attention has b scrubbing of steel sheets after pickling found to be the most serviceable materia parts of such scrubbers which must resist dilute sulfuric acid solutions encountered.

FIG. 19—*Monel pickling crate in good condition after continuous service in sulfuric acid.*

Sulfonation of Oils

MONEL IN SULFURIC ACID

of certain vegetable and animal oils sulfuric acid makes them water soluble. mable. Sulfonated castor oil, olive oil, e oils are used regularly in the leather, and other industries. Sulfonic acids s find use as constituents of soaps and and also as wetting and emulsifying

usually accomplished with 66° Bé acid ranging from 80° to 90° F. It may require teen or more hours, depending upon the and composition of the oils. In many eatment is followed by washing and neusame equipment, requiring that the equip-

FIG. 21—*Monel sulfonating, neutralizing and washing equipment used on manufacture of textile oils and specialties.*

ment resist not only the strong acid but dilute acid an sodium hydroxide as well. The results of corrosion te in several operating sulfonators are given in Table Due to variations in the duration of the sulfonation pr ess, the results have been reduced to a common basis expressed as "inch penetration per 100 batches." The conditions varied somewhat, but those of Test No. 3 typical. In this test each batch required 2,200 pour oil and 500 pounds of 66° Bé acid and lasted fifteen The temperature was 80° to 90° F. In all the tests Nos. 7 and 8, the sulfonation was followed by wate ing and neutralization with caustic as a part of cedure. Tests Nos. 7 and 8 were made during su only.

The above results are representative of the sion rates of Monel in these processes and ac superiority over other materials previously parative tests indicate that Monel is 3 to 2 resistant than lead in sulfonators and over 1 resistant in neutralization tanks. Monel is construction of complete sulfonators, lining

Monel-lined tanning drum with perforated Monel liner. Drum fastened with Monel bolts.

TABLE IV.
Corrosion Tests in Oil Sulfonation*

Solution—Various oils and various quantities of 66° Bé H_2SO_4, followed by washing and neutralization, except Tests 7 and 8.
Location of Tests—Immersed in liquid.
Approximate Temperature—16° to 60° C. (60° to 140° F.)

	Average Corrosion Rates Inch Penetration per 100 Batches (a)					
	Test 1 During 10 Batches	Test 2 During 20 Batches	Test 3 During 25 Batches	Test 4 During 14 Batches	Test 5 During 40 Batches	Test 6 During 30 Batches
	Cod Liver Oil	Yellow, Red Castor and Olive Oils	Castor and Olive Oils	Neutralized and Wash Oils	Castor Oil, 10% Sperm Oil and Olive Oil	Olive and Red Oils
Monel	0.0005 0.0011	0.0005 0.0019 (p) 0.0012	0.0008 0.0010	0.0050 0.013 (p) 0.018	0.0006 0.0010 0.0017	0.0002 0.0005 0.0004

(a) Test 6 was made in neutralizing tan in Test 7.
(d) The exact number of batches from are expected as data penetration
(e) Significant local attack in the ba

of several plants.
ion varies considerably, hence to standardize the results this unit ...ion varies considerably, hence to standardize the results this unit ...ion per year unless otherwise stated. Average production may run 150 ...ion per year. Each batch averages 12 to 24 hours.
...was made in a sulfonator with no neutralization of acid-oil mixture.

Crates, racks or baskets . . . chains, hooks, bolts, nuts, tie-rods . . . stand up for years against solutions of hot sulfuric . . . *when they're made of Monel.* Light-weight, welded Monel construction speeds up pickling . . . permits bigger payloads . . . easier handling.

Important Facts about Sulfuric Acid for Pickling Room Superintendents

A useful addition to your technical library is the INCO bulletin on Sulfuric Acid.

Here is an informative discussion of the corrosive action of various concentrations of sulfuric. All of the factors which influence such corrosion . . . acid concentrations, temperature, aeration, velocity, film formation and oxidizing salts in the solution . . . are carefully considered.

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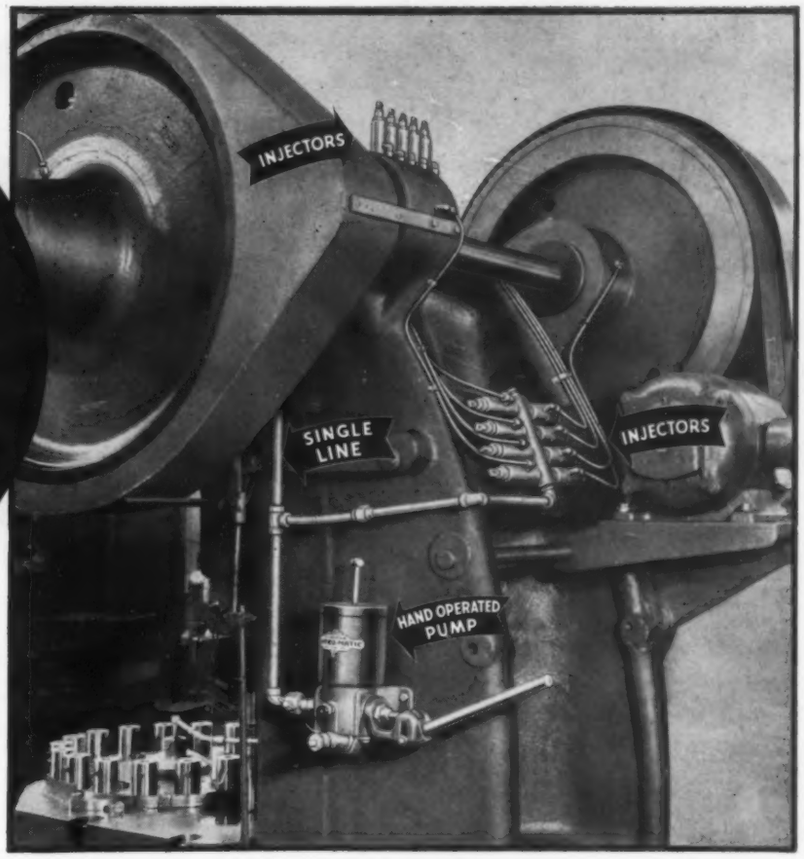

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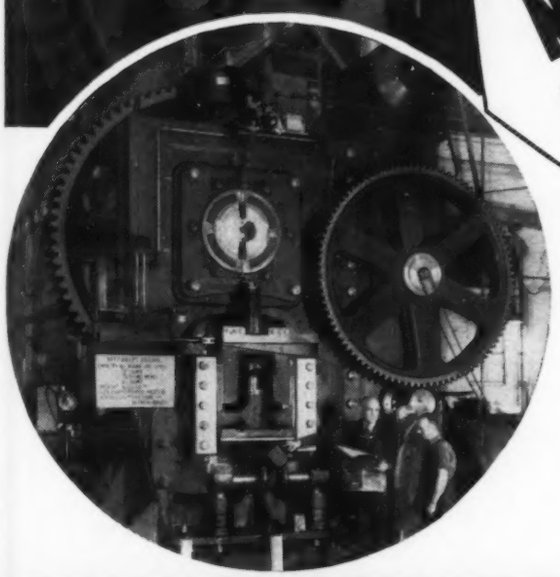
All parts finished machined after heat treating.

NELOY CAST STEEL GEARS on BUFFALO'S GIANT BILLET SHEAR

Photos courtesy of Buffalo Forge Co., Buffalo, N. Y.



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The power transmitted through the NELOY Steel Gears is indicated by the 4½ million pound pressure attained at the knives.

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The Treasury Department acknowledges with appreciation the publication of this message by

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★ the Attack . . .
★ with <u>War</u> <u>Bonds</u>!

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As Standard in
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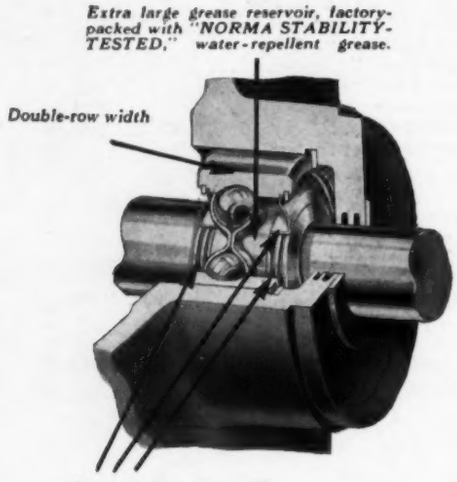
"BETTER BEARINGS FOR LONGER MOTOR LIFE"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Grease grooves and flanged, removable metal seal, on both sides, forming a wearless labyrinth barrier against escape of lubricant and entrance of foreign matter.

From the Robbins & Myers "UNI-SHELL" MOTOR Catalog:— "A motor is as old as its bearings. Good bearings and a properly designed lubricating system are the first steps in insuring long bearing life without excessive wear....The standard ball bearings are completely sealed, double-row width. Such bearings have an extra grease reservoir, insuring years of trouble-free operation."

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The steel-mill engineer who plans electrical systems knows that protective and control problems are of wide variety and that apparatus must be well suited to the particular need. To him, I-T-E brings variety of equipment. That is why, in emphasizing steel-enclosed switchgear on this page, I-T-E also lists other equipment and devices, each suited to steel-mill use.

SWITCHGEAR

Engineers in steel mills demand that electrical equipment be simple and accessible. For a long time, this requirement was filled by use of open-type switchboards. The development of drawout switchgear, pioneered by I-T-E, has led to a change. Modern I-T-E, steel-enclosed boards rival the open type in making circuit breakers accessible; disconnecting devices are simple in action and are much safer than those used for open mounting. No separate room is needed for drawout equipment; location can be guided safely by convenience or nearness to load. The circuit breakers are segregated, circuits are isolated and the enclosure brings a new measure of protection to personnel.

The I-T-E switchboard illustrated shows operators using drawout arrangements. At the left, the small circuit breaker, pantograph mounted, is nearing fully-withdrawn position where it can be readily removed, if desired. At the right, the operator is handling a large truck-mounted circuit breaker safely and easily. The entire board, with its advantages, costs little more than an open-type board built for the same duty. Send for bulletin 4207.

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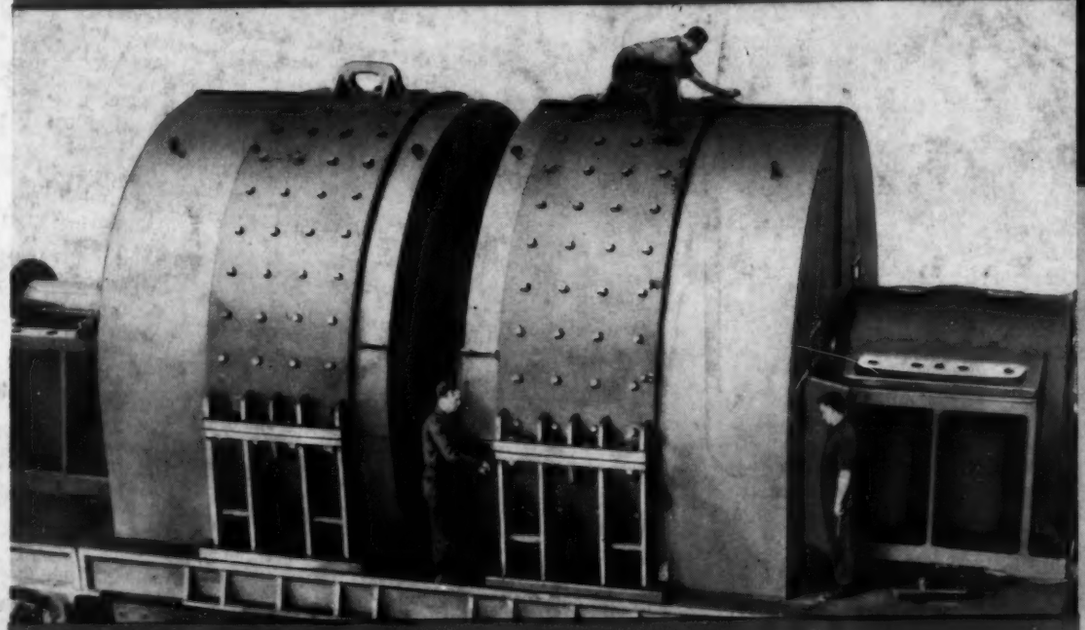

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This is another example of the application of experience and skill by G-E engineers to solve a problem created by today's needs. From the electrical standpoint, General Electric is *first:* in the number of complete-mill layouts; in installed horsepower of electric equipment in steel mills; and in special developments to solve the problems of the mill engineer. General Electric will be glad to help you meet your electrical requirements. *General Electric Company, Schenectady 5, N. Y.*

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